INSTRUMENTS AND AUTOMATION

OUR 31ST YEAR

environmental control

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The United States Testing Company, Inc., established in 1880, is an impartial, authoritative testing and research organization serving all Industry. It offers, on an international scale, these services:

TESTING. Testing and evaluation of raw materials, components, sub-assemblies, finished products, and systems.

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For more information circle **1** on inquiry card.

LEWIS SELECTOR SWITCHES
FOR RESISTANCE THERMOMETERS AND THERMOCOUPLE THERMOMETERS

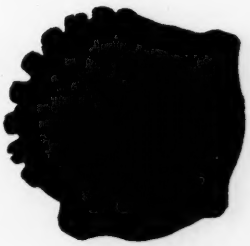
EACH SWITCH HAS "OFF" POSITION PLUS NUMBER OF POINTS LISTED.

Switch Part Numbers

Points	Size	Thermocouple Type	3 Wire Resistance-Thermometer Type
2	2″	11S2	36SR2
3	2″	11S3	36SR3
4	2″	11S4	36SR4
5	3″	10S5	37SR5
6	3″	10S6	37SR6
8	3″	10S8	37SR8
9	3″	10S9	37SR9
10	3″	10S10	37SR10
12	3″	10S12	37SR12
16	3″	10S16	37SR16
18	3″	10S18	37SR18
20	3″	10S20	37SR20
24	4″	27S24B2	38SR24
28	4″	27S28B4	38SR28
40	4″	38S2C	

(No. 38S2C is made with soldering-lug terminals)

2" SIZE



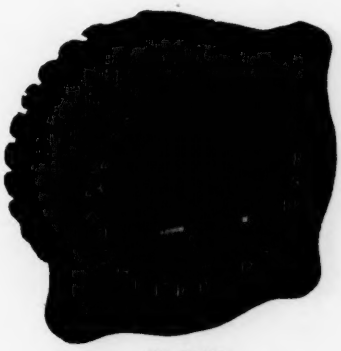
3" SIZE

SPECIAL SWITCHES

No. 37S6C2, Four "4 Point and OFF" thermocouple switches combined in one 3″ case.

No. 9S5, Single Pole, Four Point Instrument Switch in 1¼″ round case.

No. 44S4, Six Pole, Double-throw Instrument Switch in 2½″ round case, one hole mounting, ½-32 threaded bushing.



4" SIZE

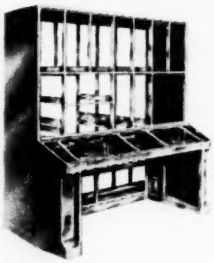
DESIGNED FOR TEST WORK AS WELL AS FOR PERMANENT INSTALLATIONS. LEWIS SELECTOR SWITCHES ARE CONSTRUCTED WITH STURDY CONTACTS OF LOW RESISTANCE AND POSITIVE DETENT. THESE SWITCHES ARE SPLASHPROOF, DUSTPROOF AND ARE BUILT TO GIVE YEARS OF SERVICE.

THE LEWIS ENGINEERING CO.
Specialists in Electrical Temperature Measurements

NAUGATUCK, CONNECTICUT

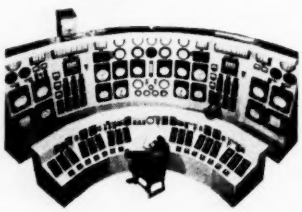
For more information circle **2** on inquiry card.

How to turn an instrument maze into a control center!

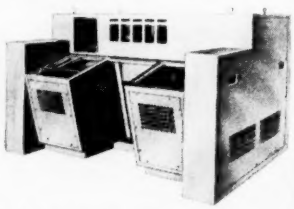


Housings are needed to bring order out of chaos, to protect instruments, assure their proper performance, and the efficient control of complex operations.

FALSTROM's many years of experience in producing custom control panels, graphic panels, consoles and housings of all kinds may help you to better design at lower cost.



FALSTROM's facilities are approved for Certified Welding and for Metal Fabrication to Mil. Specs.



FALSTROM COMPANY

Custom Metal Fabricators since 1870

109 Falstrom Court
Passaic, New Jersey

For more information circle **3** on inquiry card.

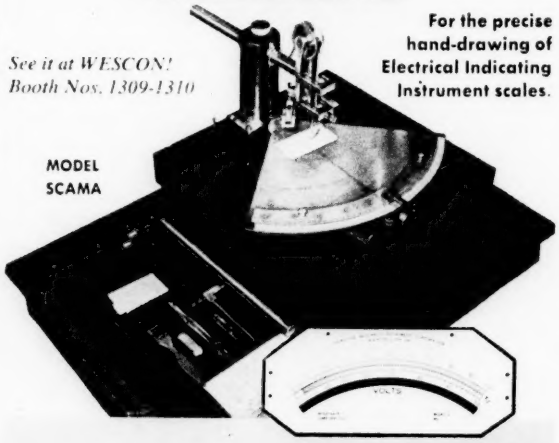
"The accuracy of an instrument is no better than its calibrated scale."

SENSITIVE RESEARCH SCALE DRAWING MACHINE

See it at WESCON! Booth Nos. 1309-1310

For the precise hand-drawing of Electrical Indicating Instrument scales.

MODEL SCAMA



Typical Hand-drawn Scale

The Model SCAMA is designed for use by ***military and industrial personnel engaged in the repair and maintenance of electrical indicating instruments.*** It is an exact duplicate of the scale drawing machines used in SRIC's own production laboratories for the past 31 years.

Drawing scale calibration lines

Wherever the efficient in-plant repair of indicating instruments is a necessity, the economies of owning a scale drawing machine are readily apparent. The best craftsmen, furnished with the finest electrical standards, are still inadequately equipped if they lack the means necessary to "wrap the job up" by restoring an instrument to its original accuracy. It is unfortunate that the one thing that is usually missing, is the equipment to correct or re-draw an instrument's scale.

The Model SCAMA is furnished complete with all the necessary accessories to draw and print any flat scale plate to infinite accuracy. Included in its price is a 40-hour instruction course at SRIC's plant.

If you are an organization or group actively engaged in the repair of electrical indicating instruments, we urge you to investigate further the potentialities of the Model SCAMA.

SENSITIVE RESEARCH INSTRUMENT CORPORATION

NEW ROCHELLE, N. Y.

Symbol of Quality

ELECTRICAL INSTRUMENTS OF PRECISION

For more information circle **4** on inquiry card.

INSTRUMENTS AND AUTOMATION

AUTOMATION: The use of devices—mechanical, pneumatic, hydraulic, electrical and electronic—for making automatic decisions and efforts.—**MHA**

JULY 1958

31

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New Concepts in Environmental Testing, 1192

INCLUDE combination environments and testing to failure rather than PET

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Control of Subway Ventilation, 1200

H. WARD TYLER—carbon-monoxide analyzers actuate fans; stop traffic, if necessary

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R. A. MINARD—viscosity measurement need not be considered merely for analytical purposes—it is often related to product's final quality

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AMPERITE PREFERRED

by design engineers—because they're
MOST COMPACT • MOST ECONOMICAL
SIMPLEST • HERMETICALLY SEALED

Thermostatic DELAY RELAYS

2 to 180 Seconds

Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.

Hermetically sealed. Not affected by altitude, moisture, or climate changes.

SPST only—normally open or closed.

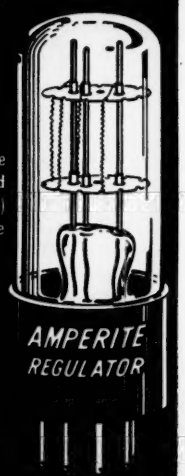
Compensated for ambient temperature changes from —55 to + 70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are **rugged, explosion-proof, long-lived,** and—**inexpensive!**

Also — **Amperite Differential Relays:** Used for automatic overload, under-voltage or under-current protection

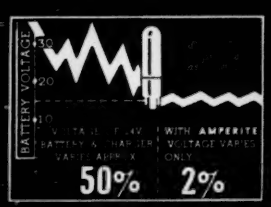
TYPES: Standard Radio Octal, and 9-Pin Miniature . . . **List Price, $4.00.** Standard Delays

PROBLEM? Send for Bulletin No. TR-81

BALLAST REGULATORS



Amperite Regulators are designed to keep the current in a circuit **automatically regulated** at a definite value (for example, 0.5 amp.) . . . For currents of 60 ma. to 5 amps. Operate on A.C., D.C., or Pulsating Current.



Hermetically sealed, they are not affected by changes in altitude, ambient temperature (—55 to + 90° C.), or humidity . . . Rugged, light, compact, most inexpensive . . . **List Price, $3.00.**

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For more information circle **5** on inquiry card.

INSTRUMENTS and AUTOMATION

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Instruments and Automation (including Instrument Manufacturing) published monthly by The Instruments Publishing Company, Inc. Office of publications, 1600 North Main Street, Pontiac, Illinois. Executive and Editorial Office, 845 Ridge Avenue, Pittsburgh 12, Pennsylvania. Second Class mail authorized at Pontiac, Illinois.

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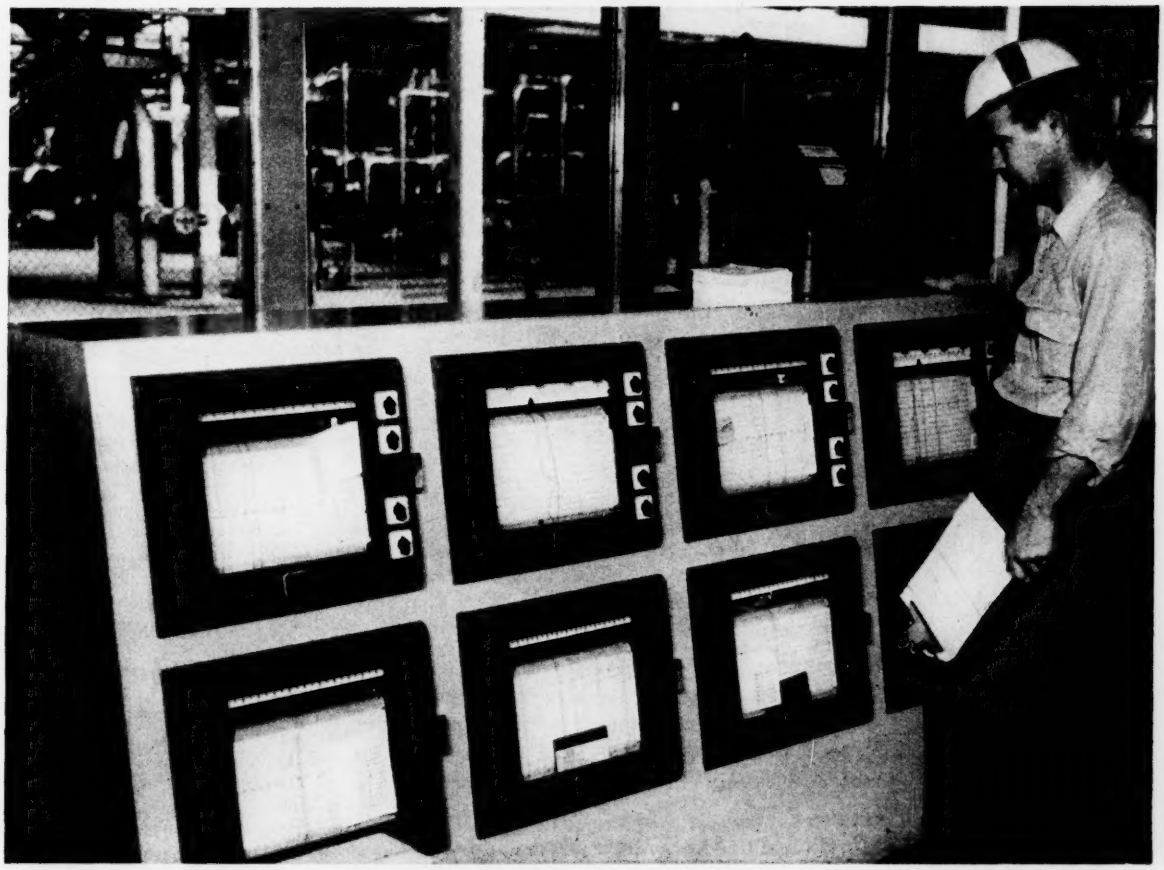
"MILLION-DOLLAR" CONTROL SYSTEM

spots trends with Bristol recorders



THESE MULTIPLE-CHANNEL BRISTOL TREND RECORDERS—one of several such groups—can spot troubles before they start at the Delaware Refinery of Tidewater Oil Company. All of the self-balancing bridge and potentiometer instruments in this modern plant are Bristol's. Instrument system designed and installed by Panellit Inc., Skokie, Illinois.

Designed to nip trouble in the bud, the "million-dollar" control system at the Delaware Refinery of Tidewater Oil Company features the latest analogue-to-digital scanning and logging techniques—and several batteries of patchboard-connected Bristol Dynamaster* trend recorders that can display almost any variable measured or controlled in the entire plant.

This uniquely flexible system lets the operator, in any of the plant's nine control rooms, record only those variables that need close, continuous checking. He simply plugs the recorders into the desired circuits at the patchboard and gets continuous records as needed.

Bristol Dynamaster electronic instruments are ideal as general-purpose recorders like these, and for special applications, too. The Dynamaster's high accuracy, outstanding flexibility, extremely broad range of accessory equipment, easy adaptability and exclusive features like No-Batt Continuous Standardization make it a consistent favorite among instrument men everywhere.

Find out how Bristol instruments—the most complete line of full-sized and miniature electronic and pneumatic instruments on the market—can help solve your difficult problems in recording, indication or automatic control. Write: The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

T. M. Reg. U. S. Pat. Off. 8-8

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle **6** on inquiry card.

When WEIGHT and SIZE are Critical...

. . . consider ARNOUX's new, transistorized, high-sensitivity, miniature temperature-measurement subsytems for missile and aircraft flight testing.

This newest series—TME-1SD and TME-2SD—are for use with fast-response, 100-ohm resistance temperature transducers to produce a full 5-volt output for a span of only 75 F. TME-1SD is a single-channel model; TME-2SD, a dual-channel model.

The unit contains a regulated power supply, transistor amplifier, and gain and zero controls. No additional power source or controls are needed.

Nominal, overall accuracy is ±2.5 percent throughout MIL-E-5272A environmental conditions. Power consumption is 26 watts (TME-1SD) or 27 watts (TME-2SD), at 28 vdc. Output impedance is approximately 10,000 ohms. The bridge can be balanced for zero output setting at any temperature from −320 F to +250 F. Gain adjustment allows full-scale span to be varied. Maximum drift over the environmental temperature range is ±2 percent of full scale.

For further information write for Bulletin 503

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to the editor

Editor, I&A:

In reading the feature "Trends" in your April issue, I was interested in the comment about the lag in apprentice training. Farsighted people in both Labor and Management have recognized this for quite some time, but are having trouble bucking the system of "upgrading" which was substituted for apprenticeship during World War II. Now, it is hard to find a young man who is willing to tie himself down for a period of four to six years at, what he thinks, is a low wage. Too many times the apprentice feels he should be given a raise and put on a machine just because he can do several operations on it. This led to upgrading and semiskilled workers. The present trend to automation will really strain the entire labor picture in its need for highly skilled workers.

I left Industry (Tool and Die Maker) in 1954 to go to Mississippi State College as an Instrument Maker in the Aerophysics Department. Here I ran into another condition which has not been brought out. Educational institutions need men in their shops to develop and build the equipment necessary to the research programs being carried out there. These shop men must be more than just a machinist or tool maker. They must be able to translate the idea that theory has developed without the benefit of engineers to clear up detailed plans. They must be able to turn out a job without the unlimited facilities of machine and material found in Industry. Where are these men being trained?

This question was outstanding in my mind when I came to Oklahoma State University to plan and build a Research Shop for Physics and Chemistry in 1956. In 1957, the Heads of these Departments let me start a young man on a six-year apprenticeship. As far as I can check, this is the first campus to undertake such a program. I think that other colleges and universities can do the same thing.

Industry should recognize such an effort since it will help in the long run to turn out research scientists. In fact, in many cases Industry could help programs such as this by donating items of equipment that are in good working order but have been set aside as outdated. I am sure that research shops and cam-

puses over the entire country would be grateful for such items.

Let us all hope that Labor, Management and Educational Institutions will recognize the need for skilled men soon—and do something about it.

Rupert C. Robertson
Instrument Maker, Physics Dept.
Oklahoma State University
Stillwater, Okla.

The last four words in this fine letter are the key ones!

Editor, I&A:

We are planning a series of articles on electronic computing and automation in our company publication *The Beacon*. We would like to know what manner of suggestions or help you may give us. The articles are in the planning stage and we have not decided on art work or illustrations as yet. Was wondering if perhaps you people have a publication that you distribute.

Eugen L. Price
The Ohio Oil Co.
Findlay, Ohio

We suggest that you consult our books *Digital Techniques for Computation & Control, Computer Handbooks,* and the *Automatic Factory;* also our many editorials in *INSTRUMENTS AND AUTOMATION.*

Editor, I&A:

We were surprised to find in the April issue of your excellent publication under the heading "Trends" the statement, that "nobody makes temperature controllers" in Australia.

We manufacture temperature controllers, both dial type and mercury in glass. Our two factories which have been established for many years in Melbourne are devoted entirely to the manufacture of all types of thermometers and temperature instruments. We also distribute and service pyrometric type controllers.

If, as a result of your feature article, any American manufacturers are interested in this field we would welcome enquiries.

Norman C. Dobbie
Dobbie Bros. Thermometers PTY. LTD.
Melbourne, Victoria
Australia

RAMBLINGS ON INSTRUMENTATION

Happy Birthday, Dear British Thermal Unit!

The British Thermal Unit is 177 years old this month. In today's chaotic world it is indeed comforting to find this doughty old symbol standing virtually alone in its field[1], unchanged, unchallenged, a thermal Rock of Gibraltar in the turbulent seas of science. (Knowledgeable engineers have long recognized that the common calorie simply lacks the class of the BTU.)

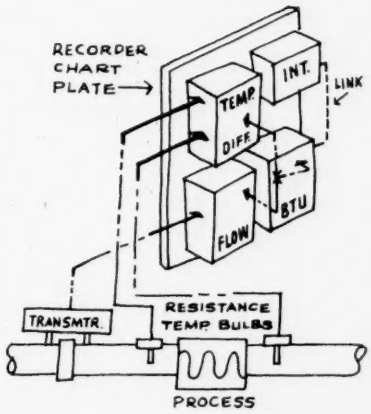
Between crumpet breaks in Hays' internationally oriented engineering department, we have prepared a fitting birthday tribute to jolly old BTU—the Hays Mark VII, (by special arrangement with Jack Webb) BTU recorder.

This indefatigable Boswell of the BTU provides a highly accurate diary of thermal behavior—and misbehavior—in water flow and other applications. Using a remote flow transmitter and resistance temperature bulbs, it produces *linear* records of flow, Delta T and BTU, plus integration of BTU.

More good news for you dyed-in-the-wool BTU buffs is the fact that all operating elements are mounted with grim determination on the $^1/_4$" cast aluminum chart plate, which has two-point suspension to prevent those deplorable shifts in readings due to mounting of the case on uneven surfaces. The sketch above, prepared by our draughting loft, may or may not clarify all this.

In operation, the product of temperature difference and flow is fed to the BTU receiver unit. The continuous mechanical integrator is loaded by this unit through linkage to provide a necessary total of BTU.

[1]The British have not always had the thermal unit field to themselves, of course. The Texas Thermal Unit, developed during the Civil War, eventually proved too unwieldy for use elsewhere. There was also the "America-First" Thermal Unit, sponsored by a clique of midwestern Anglophobes, which won brief support in the early '20's. Drop these informative tid-bits into a conversational lull sometime and watch the admiring glances.



Faithful Boswell of the British Thermal Unit the Hays Mark VII BTU Recorder.

Less than $1,800 will put one of these recorders in your plant, office or bath. Comes complete with temperature resistance bulbs, orifice plate and leather carrying case. We pay postage. Do your bit for Anglo-American relations. Get to *know* your BTU's. Buy a Hays Mark VII BTU Recorder.

Reading about the Universal recorder is no substitute for the real thing, of course, but if you prefer your thrills vicariously, write for Hays bulletin 58-1240-137. Most illuminating.

. . . And For The Colonies . . .

Realizing that not everyone has real imported BTU's in their pipeline, we have designed the Universal recorder to cope with practically any other application of a cruder nature. We would, as they say in the States, like to give your unusual recording problem a whirl. Why not drop me a line with the details?

Thos. A. Sprague

President

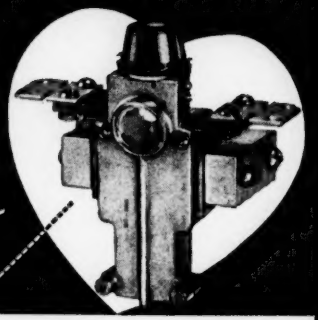
THE HAYS CORPORATION • MICHIGAN CITY 8, INDIANA

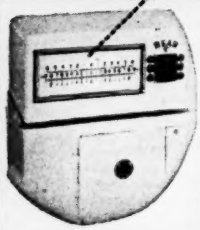
For more information circle **8** on inquiry card.

Make a GM PORTABLE D'ARSONVAL

GALVANOMETER

the Heart of Your Instrument





IN THE AUTOMOTIVE FIELD, the Bear Manufacturing Co. of Rock Island, Ill. uses Series 500 G-M Galvanometers in its new remote-reading Electric Wheel Alignment System (left). Whatever your own particular instrument field, you can achieve this same self-contained portability, ruggedness and high sensitivity with G-M Galvanometers. Complete catalog on request.

GM LABORATORIES • INC.

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BY Dwyer

NOW AN ALL-PURPOSE LOW-COST INSTRUMENT FOR STATIC PRESSURE AND AIR VELOCITY MEASUREMENTS

High *and* low ranges give direct velocity readings from 260 to 4000 fpm., static pressure readings from .005 to 1.0 inches of water. A complete instrument kit with every accessory needed for adjusting and balancing air conditioning, heating and ventilating equipment. The entire kit will fit in your shirt pocket.

SUPPLY GRILLE VELOCITY

RETURN GRILLE VELOCITY

OVER-FIRE AND SMOKE PIPE DRAFT

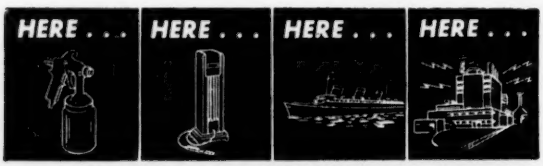
STATIC PRESSURE

WRITE FOR BULLETIN B-9

F. W. DWYER MFG. CO.

P. O. BOX 373-S MICHIGAN CITY, INDIANA

For more information circle **99** on inquiry card.



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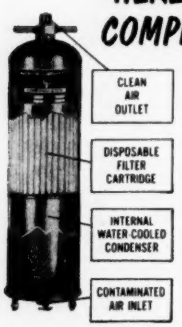
HANKISON *Condensifilters*

for INSTRUMENT-QUALITY COMPRESSED AIR

HERE IS YOUR ANSWER TO COMPRESSED AIR PROBLEMS



From steel companies to steamships . . . from paint spray equipment to power plants . . . wherever POSITIVE PROTECTION for pneumatic instruments and controls is required, Hankison Condensifilters are specified.

Condensifilters eliminate:

- Moisture, *entrained and vaporized*
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Write today for Bulletin M-7155R.

HC-12 *Condensifilters are ASME coded.*

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For more information circle **98** on inquiry card.

ESCO ROTARY SWITCH CATALOG

Low-cost Dependable Rotary Multipole Switches

This new 20-page catalog gives you detailed engineering data, electrical ratings, dimensioned drawings of switches and knobs, cutaway and exploded views of the ESCO line. Write for your free copy.

ESCO of WEYMOUTH

ELECTRO SWITCH CORPORATION

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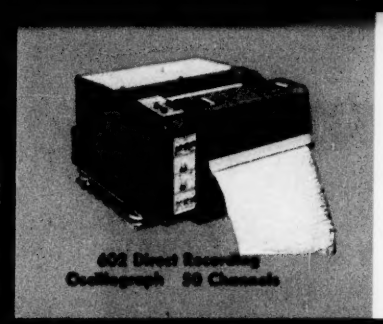
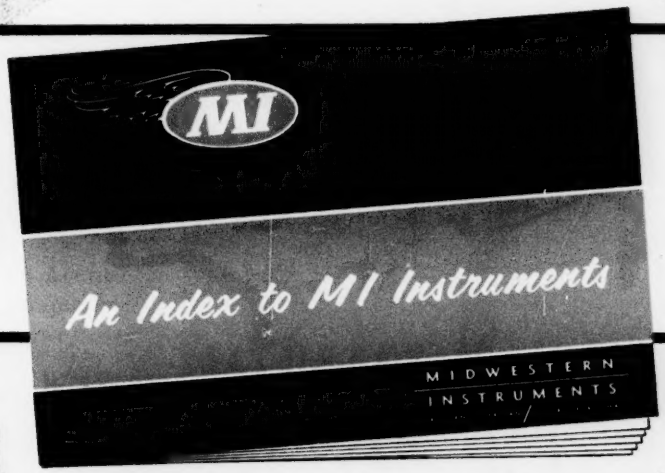
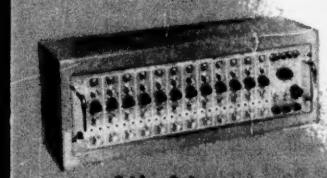


MIDWESTERN'S specialization is the design and manufacture of instruments with unexcelled operational characteristics. MI instruments are engineered to deliver uninterrupted accurate results under the stresses of multiple "G's" produced by vibration, shock, and extremes in adverse environmental conditions.





Catalogs and Brochures upon Request

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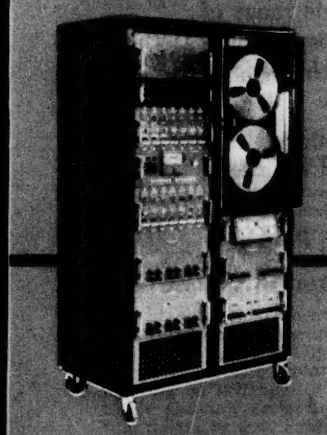

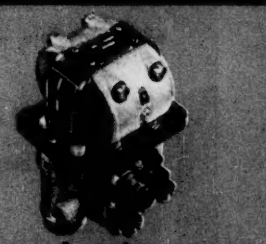

MIDWESTERN
INSTRUMENTS

41ST AND SHERIDAN / TULSA, OKLAHOMA

Phone Riverside 7-1331

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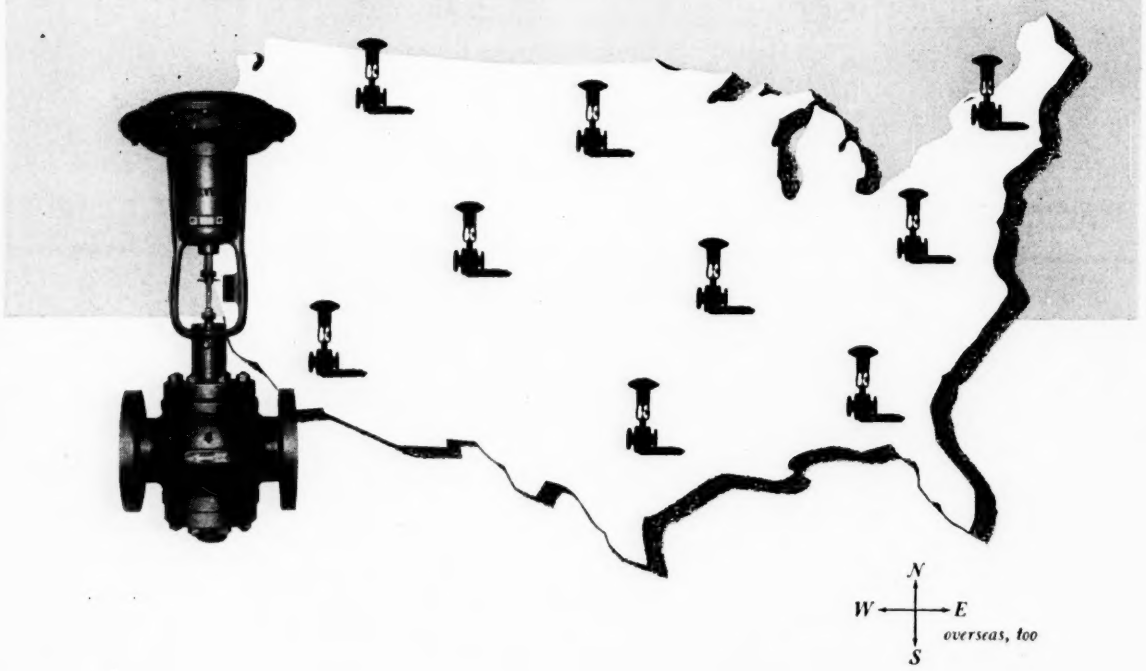
where do you want your control valves?



Honeywell control valves are bought locally...serviced locally

Wherever you may be . . . there are Honeywell field engineers as near as your telephone . . . to sell and service *quality* control valves for your process needs.

Name the construction, material and size . . . Honeywell quality control valves are available in a wide range of types and sizes to meet your specific application requirements. From specification to startup, followed by periodic service . . . you're way ahead with Honeywell.

Next time you need control valves . . . why not do as others are doing . . . give your local Honeywell field engineer a call or write for literature.

MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.

Honeywell

112 branch offices from coast to coast

H HONEYWELL *First in Control*

LETTERS—CONTINUED

Editor, I&A:

Dr. Killian has asked me to thank you for your monograph on the Automation Course at Allegheny High School.

Dr. Killian has long felt that education of technicians and technically competent individuals has lagged behind the needs of our industrial society. The need for more sound technical education is acute to fill the laboratories and factories with those who can understand and operate equipment and machinery of advanced design.

The material you submitted has been brought to the attention of the Education Panel of the Science Advisory Committee.

Henry Loomis
Staff Director
Office of the Special Assistant for Science and Technology
The White House, Washington

Reader Inquiries

Fifty Millionths Inch Accuracy Sought in 60″ Diameter

Chief designer of Industrial Design company writes as follows: "One of our client's machines rolls (steel, rubber, composition, etc.). They are searching for a sensing head which will give diameters on straight or crowned rolls at a positive accuracy of 0.00005". Presently they use a dial indicator in a type of caliper tongs. This is not accurate enough. The caliper is rolled along the roll from one end to the other. The range of the indicator should be ½". The rolls are sometimes measured on the floor unsupported or in a roll grinder, or sometimes in calendar stacks which expose only 90 to 100 degrees of the face. These rolls vary from 4" to 60" in dia and can be 350" long. Calipers will have to be used in production so they must be simple . . .

Do you know of anything (electronic, ultrasonic, optical) that might offer some solution to this problem?"

A-324

Directory For Air and Instrumentation

Advertising department of plastics manufacturer is interested in obtaining a directory in the "Air and Instrumentation fields." A-325

Rotary Humidifier

Australian instrument dealer seeks information for government office on 15"-dia (approximately) humidistat or time-controlled "rotary humidifier" working on principle of fan throwing water through series of sieves until fine mist emerges. Said to be American made. A-326

HEISE GAUGES

NEW Automatic Thermal Compensator

MAINTAINS ACCURACY REGARDLESS OF TEMPERATURE VARIATIONS

Another exclusive feature developed by the makers of the world's most PRECISE PRESSURE GAUGES

- NO THERMAL READJUSTMENT OF DIAL ZERO
- NO CORRECTION CURVE COMPUTATIONS
- DIRECT DEPENDABLE READING AT TEMPERATURES FROM 0° TO 100°F.

Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"-12"-16"
Prices from $196.75 DELIVERY WITHIN 30 DAYS

Write for Catalog

HEISE BOURDON TUBE COMPANY, INC.
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle 11 on inquiry card.

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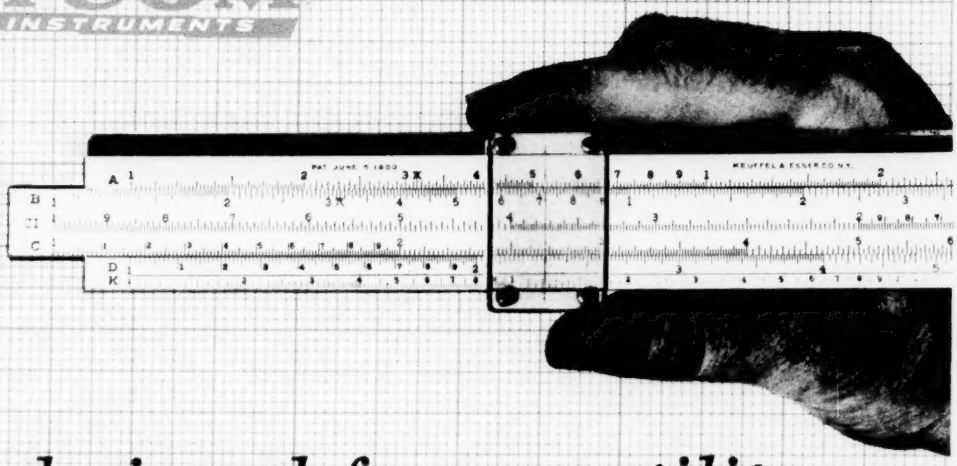
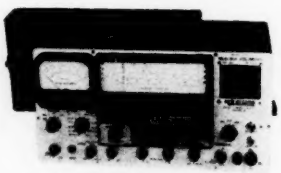
INSTRUMENTS



. . . designed for versatility

Superior quality Rycom test equipment has been performance proved by leading companies all over the world. Rycom gives you fast, accurate measurements, functional design, and long service life.



RYCOM MODEL 2174
FREQUENCY SELECTIVE VOLTMETER

This instrument utilizes the heterodyne principle with balanced modulation and highly selective crystal filter which achieve the high resolution needed for measurements of telemetering sub-carrier, microwave sub-carrier and carrier telephone channelling equipment.

RYCOM MODEL RM 24 OSCILLISCOPE—features multi-channel oscilliscope XY display, general purpose, bar chart, or slave indicator. Available in either console and table model.

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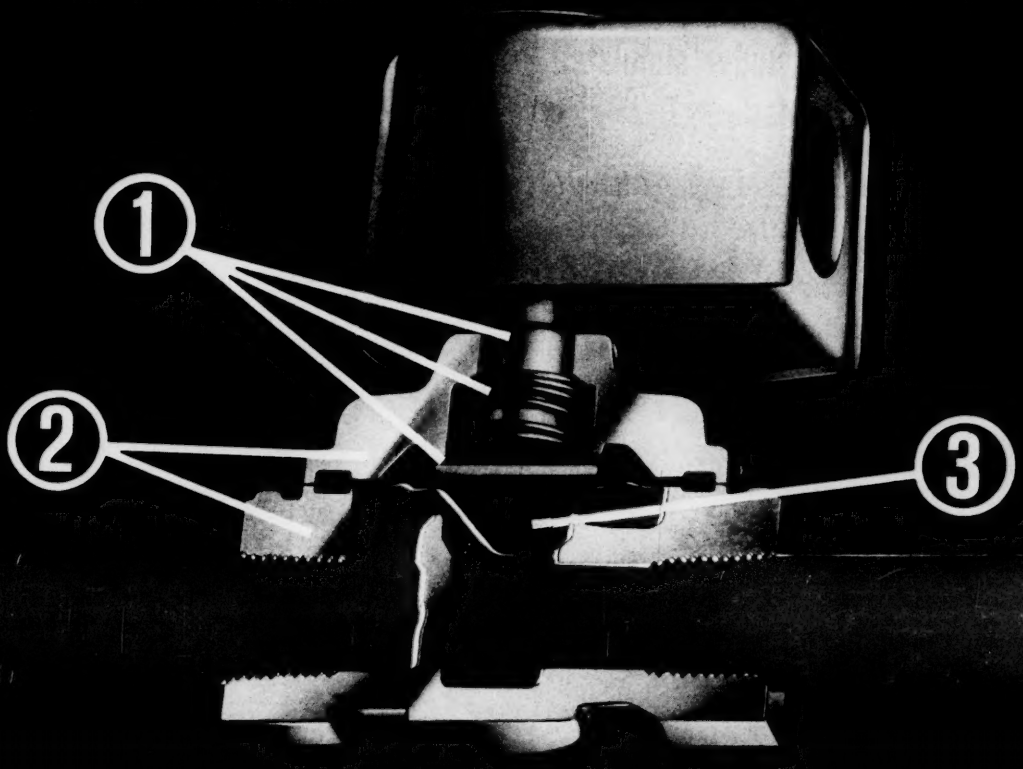
ALSO MANUFACTURERS OF: SELECTIVE VOLTMETERS • PRINTER MOTOR CONTROLLER • MICROWAVE CHANNELLING CARRIER, TELEPHONE & TELEGRAPH TERMINALS • CUSTOM TOROIDAL REACTORS & TRANSFORMERS • FILTERS; LOW PASS — BAND PASS — HIGH PASS • CUSTOM TEST EQUIPMENT • LARGE SCREEN OSCILLOSCOPES

For more information circle **12** on inquiry card.

Circle **13** on inquiry card. ⟶

SIMPLICITY, RUGGEDNESS, TIGHT SEATING,



WITH ASCO'S COMPLETE LINE OF 2-WAY SOLENOID VALVES

ASCO general purpose packless valves are now provided in a full ⅜" to 3" range . . . handle pressures up to 350 p.s.i. . . . ½" and ¾" sizes available to 1500 p.s.i. . . . provide dependable flow control for air, gas, water, light oil and other non-corrosive fluids.

Check these features of the Bulletin 8210A:

1. **Simplicity** in construction: Only three operational parts: all stainless steel core, stainless steel spring. Hycar diaphragm, ⅜"-¾" sizes . . . bronze piston ¾"-3" sizes.
2. **Ruggedness:** Forged brass bonnet and body insure freedom from porosity.
3. **Tight shut-off:** Assured by resilient disc construction.

Compactness: 2¾" face to face; 3¼" pipe center line to top of solenoid; 3-13/16" overall height. (Normally closed, ⅜" x ½" sizes.)

Mountable in any position: Normally open or normally closed.

Fast action: Rapid filling-venting operation permits cycling rate to 400 per minute.

All sizes have full area ports, continuous duty coils designed for low temperature rise and long life, and are available normally open or normally closed with standard, water tight or explosion proof solenoid.

Whatever the crucial factor in your flow-control application – reliability, compactness, high cycling rate – there is an ASCO valve that meets your need.

For Immediate Delivery . . .

World's largest stock of Solenoid Valves. A complete Solenoid Valve Stock List will be sent to you with your copy of Catalog No. 202.

New! Catalog No. 202 covers the ASCO line of Solenoid Valves. Write for your copy today.

See Us At The ISA Show Booth 1247 Sept. 15-19

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AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO®

Which one of these Genisco centrifuges meets your requirements for testing components under simulated operational G-loadings?

...as required by Mil 5272A, procedure II

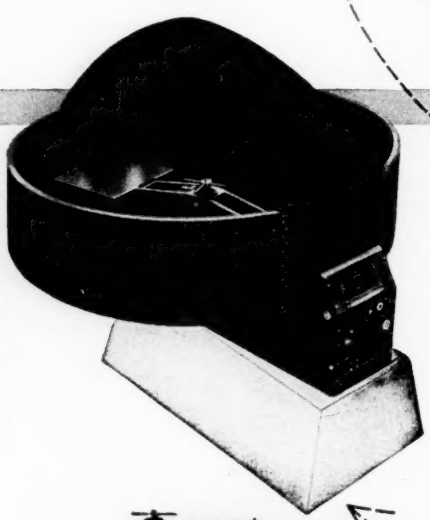
Genisco G-Accelerators provide a quick, precise means of testing components in an acceleration environment similar to that encountered in actual operation.

They are extremely accurate machines, easy to operate and built to withstand years of hard use.

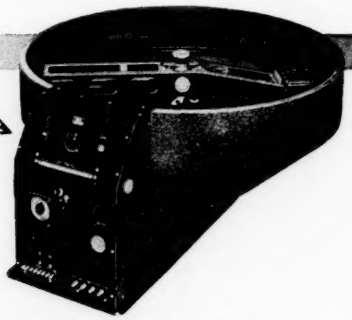
These features particularly suit them for large volume testing programs, as well as for precise laboratory prototype development.

More than 250 Genisco G-Accelerators of various capacities are now in use throughout the world.

Complete technical information on all models and accessories is available. Please direct your inquiry to: Contracts Manager, Genisco, Inc., 2233 Federal Avenue, Los Angeles 64, California.



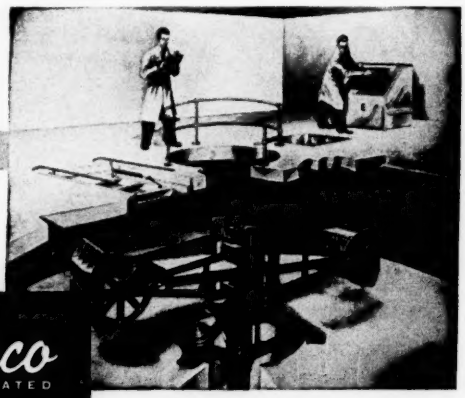
MODEL C159 The larger capacity of this machine permits whole system components and complete packages to be tested. Two objects, each weighing 100 pounds and 24" x 24" x 18" in size, can be accommodated simultaneously. G-range of the machine is 0.024 G to 75 G's. Maximum centrifugal capacity is 2000 G-pounds. Nominal radius of gyration 48".



MODEL B78 Used primarily for testing relays, switches, tubes, motors, valves, and other small components, and to calibrate and evaluate accelerometers. Accommodates objects weighing up to 25 lbs.; has G-range of 0.017 G to 120 G's. Maximum centrifugal capacity is 1200 G-pounds. Nominal radius of gyration 24".

MODEL D184 A high-speed machine, designed to test accelerometers and other instruments under acceleration forces from 1 to 850 G's. Full centrifugal capacity is 1000 G-pounds. Nominal radius of gyration 12".

MODEL E185 This newest and largest Genisco centrifuge was recently built for the U.S. Air Force. Two mechanical or electronic packages, each weighing up to 300 pounds, can be subjected to an acceleration environment of up to 65 G's simultaneously. Nominal radius of gyration of the machine is six feet. An automatic dynamic balancing system automatically compensates for any excessive unbalance in the machine during test runs.



ACCESSORIES ADD TO OPERATING EASE A number of accessories including a strobe system, air system, optical system, tub cover, access doorway, and slip ring systems, designed to give greater operating convenience, are available for Genisco G-Accelerators, Models B78 and C159.

Modifications in any basic machine or accessories to meet your particular requirements will be carefully considered.

Genisco INCORPORATED

RELIABILITY FIRST

For more information circle **14** on inquiry card.

Electron receiving tube market in 1958 will reach 490 million units, with factory value of $430 million, says R. Sampson, Market Research, RCA, owing to demands of data-processing industry. This is 7% above 1957. Replacement market in 1958 will reach 190 million units, of $157 million value. Semiconductors are expected to reach $200 million in 1958, up 35% over 1957.

Reliability and qualification testing of components is now a $25 million annual market, reports Electronics Industries Association. Other estimates place this market as high as $50 million.

Instrumentation problems associated with space flight include tremendous temperature changes to be expected. Batteries become useless at minus 300 to 400°F, but circuit conductance increases; transistors operate well at lower temperatures, and solar cell voltage increases. Research into very-low-temperature operation of batteries, solar cells, transistors and semiconductors is underway. New techniques may include making use of high vacuum of outer space by having electronic equipment outside the space vessel. Effects of weightlessness of the human being will be another primary problem.

Commercial electronic test equipments are now made by 368 companies in the United States, reports Technical Information Corporation of New York City. Of these, 41 companies (11%) have been marketing this type of equipment for less than one year. In addition, there are 19 foreign firms selling electronic test equipment in this country, primarily British and German organizations. 82 companies offer "off-the-shelf" d-c power supplies; 50 others offer custom supplies.

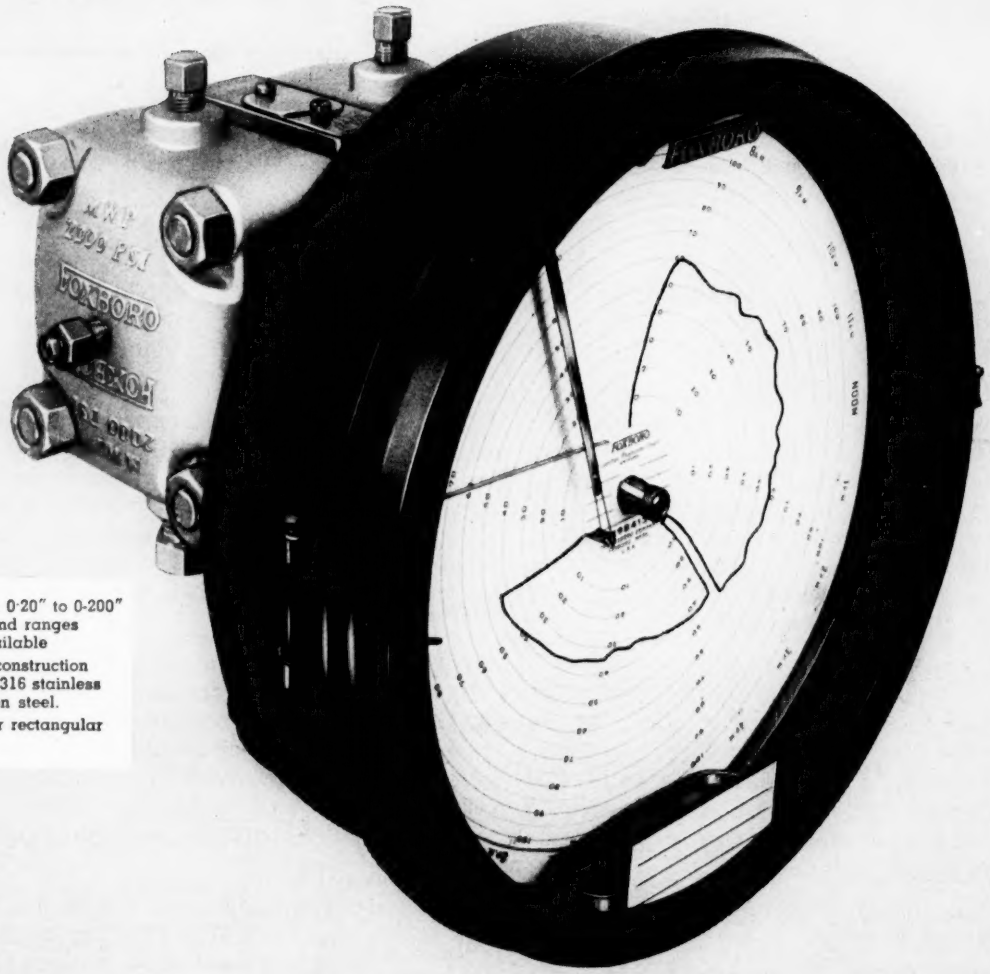
Iron and steel instrumentation developments in England, reported in 1957 survey by British Iron & Steel Research Association (BISRA), include instruments and techniques for (1) removing sulfur from iron and steel, (2) closed-loop control of forges, (3) stacklining life improvement, (4) air pollution and gas cleaning, (5) translator control—automatic control of ingot and rolls in rolling, (6) "telecentric" viewing of hot ingots to give dimensions and shape, (7) making steel with oxygen, (8) self lining of stacks by trapping the burden at intervals, (9) new techniques for micro-analysis by electron probe, (10) new disappearing-filament pyrometers, (11) new performance recorders using paper tape, and (12) new lamination detector for detecting laminations in steel sheet.

U. S. electronics volume should approach $14.5 billion this year, compared with the $13.2 billion recorded for 1957, says D. C. Duncan of Beckman/Helipot.

Electronics market reached $7.5 billion in 1957 to become 5th largest manufacturing group in U. S., reports EIA.

Electronics represent about 16% of total Air Force budget, 10% of Navy budget, 7% of Army budget. Total electronics expenditures of all three is expected to exceed $4.5 billion in fiscal '59.

NOW... a "Dry" Flow Meter with..

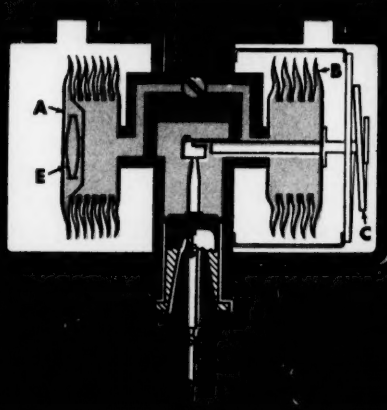


- Ranges: 0-20" to 0-200" Compound ranges also available
- Forged construction in Type 316 stainless or carbon steel.
- Round or rectangular cases.

..the new Foxboro Type 37 Diaphragm Meter

How It Works

In schematic drawing at right, areas shown in color represent a stable, non-freezing liquid. Any pressure increase in the high pressure chamber compresses Diaphragm Unit A, displacing its liquid and expanding Diaphragm Unit B until force of Range Spring C equals the difference between the forces on Diaphragm Units A and B. Linear motion of Diaphragm Unit B moves inner end of Drive Bar D — outer end moves correspondingly through the bellows-sealed flexure bar, driving pen arm. Built-in Temperature Compensator (E) proportionately adjusts diaphragm capacity as ambient temperature variations affect volume of filling fluid. External damping adjustment is shown at F.



• complete overrange protection!

• sustained high accuracy!

Now you can have mercuryless flow measurement for a wide range of differential pressures — at static pressures up to 2000 psi — with greater safety and dependability than ever before!

The new Foxboro Type 37 Diaphragm Meter not only combines unmatched ruggedness and precision in a dry meter — it's by far the easiest to adjust and maintain. And it does away with zero drift problems, once and for all!

Expansible, Type 316 S.S. diaphragm elements respond to changes in pressure with unmatched sensitivity, yet are completely immune to overrange up to full static pressure! A unique packless drive bar precisely transmits linear motion to the pen arm. Range-changing is easy, due to new twin-spiral spring design. Wide range damping is externally adjustable under pressure. And the Type 37 is self-compensating for temperature changes in all differential ranges.

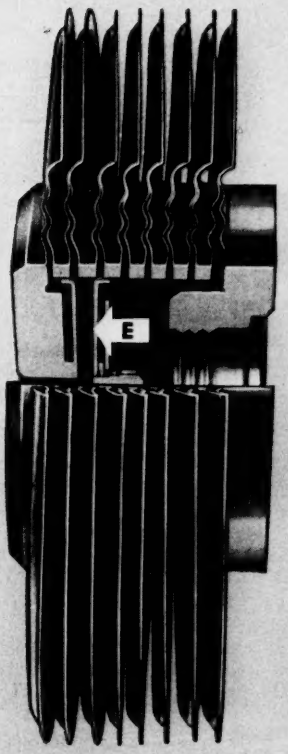
Get full details on this high utility, completely dependable dry flow meter. Arrange for a demonstration with your nearby Foxboro Field Engineer, or write **The Foxboro Company, 467 Neponset Avenue, Foxboro, Mass., U.S.A.**

FOXBORO

REG. U.S. PAT. OFF.

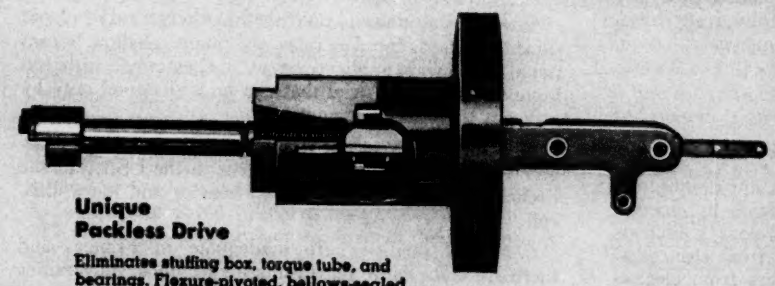
FIRST IN FLOW METERING

For more information circle **15** on inquiry card.



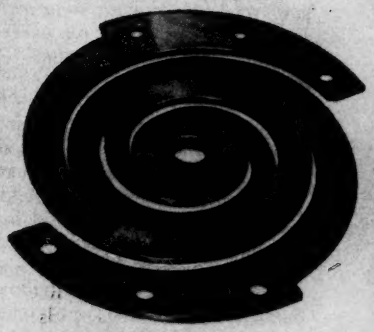
Exclusive Diaphragm Elements

Type 316 S.S. diaphragm units in both high and low pressure chambers provide greatest linearity and freedom from hysteresis; nesting design and integral spacer rings provide safe, positive, overrange protection. Temperature compensation (E) is built into diaphragm assembly . . . never requires change or adjustment.



Unique Packless Drive

Eliminates stuffing box, torque tube, and bearings. Flexure-pivoted, bellows-sealed drive bar transmits diaphragm's linear motion to the pen arm with unequalled sensitivity and undiminished power. Seal for flexure pivot is a tough, flexible bellows.



Exclusive Range Springs

Heavy gauge Ni-Span C alloy, twin-spiral springs provide high sensitivity with lasting accuracy. Readily accessible . . . range changes are easily made, in minutes!

news

Crisis in Leak Detection

WASHINGTON, D. C.—Owing to a shortage in helium, the U. S. government is asking for a 70% "across the board" decrease in helium use. This will put quite a dent in ultra-sensitive detection activity because approximately 10% of helium consumption is for leak detection.

This sets the stage for the halogen-type leak detectors, which, except for the helium types, are the most sensitive detection devices available. (General Electric has announced a new line of halogen leak detectors.)

Leak detection is a "must" in the development of nuclear reactor components, cyclotrons etc. and in the electronics industry—leak testing of transistors, relays, and hermetically-sealed instruments. Fuel systems and components on missiles are another important area for leak-testing.

Break-through in Data Processing—Automatic Error Correction

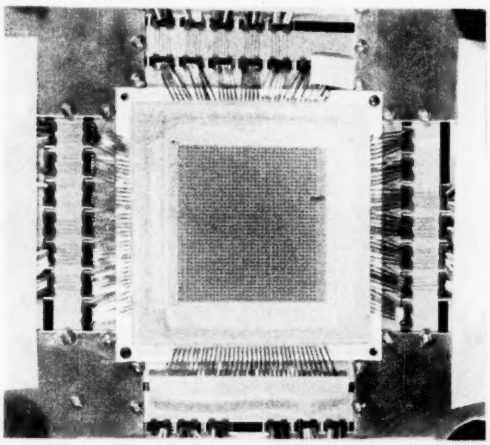
NEWTON HIGHLANDS, MASS.—Datamatic Div. of Minneapolis-Honeywell has devised a new self-correcting system, called Orthotronic Control, which literally recreates source data and provides instant data reconstruction of lost or garbled words or figures when discrepancies are automatically spotted at any of a series of check points.

All data-processing systems today have built-in detection methods by which the machine in effect proof-reads its own material and monitors by ringing a bell, flashing a light, etc., but they require tedious manual searching of files, or time-consuming re-runs of the tape. OC's nonstop retrieval of data requires no human intervention. In fact it will relay to the operator a typed note informing him that a passing mistake has been discovered and fixed.

The key development of the new control is that it actually regenerates data a split second *before* they are processed whenever a mistake shows up. This is accomplished by combining mathematical principles with electronic performance in constantly cross-examining each fragment of every letter and figure as it is measured in the dot-dash impulses of speeding electronic tape. By sensing and correcting errors in the code signals which make up fractions of individual letters and digits, lost, damaged or garbled words can be literally resurrected and restored to their proper sense and sequence.

Color Readout Display

HOLLYWOOD, CALIF.—Electroflors are unique materials which respond to electrical activation by changes in color. A normally colorless type develops a blue or red zone of color by electrical impulses from electrodes. This response of subtractive color differs from electroluminescence in that no light is radiated from the Electroflor device. Instead, a color effect is produced which can be observed even in direct sunlight.



The experimental Electroflor matrix cell illustrated will show as a pattern of dots of color appearing at the intersection point of each pair of energized electrodes. Displays of this kind could be utilized to advantage in aircraft instrumentation and airport landing control, numerical readouts, data storage devices, etc. Electroflor devices lend themselves readily to transistorized circuitry as only a few volts are needed for energizing, and current is in the microamp range. Electroflor is manufactured by Electroflor, Inc., Hollywood, Calif.

French Mission Meets With I&A Staff

PITTSBURGH, PA.—Members of the French Mission E.D.F., who came here under the auspices of International Cooperation Administration to investigate "automation in the conception and exploitation of the important steam and hydraulic power plants," visited the offices of the Instruments Publishing Company on May 26. Their discussion with the editors of INSTRUMENTS AND AUTOMATION brought out the following points:

1. America is the least standardized country in the world in terminology and units of measurement.

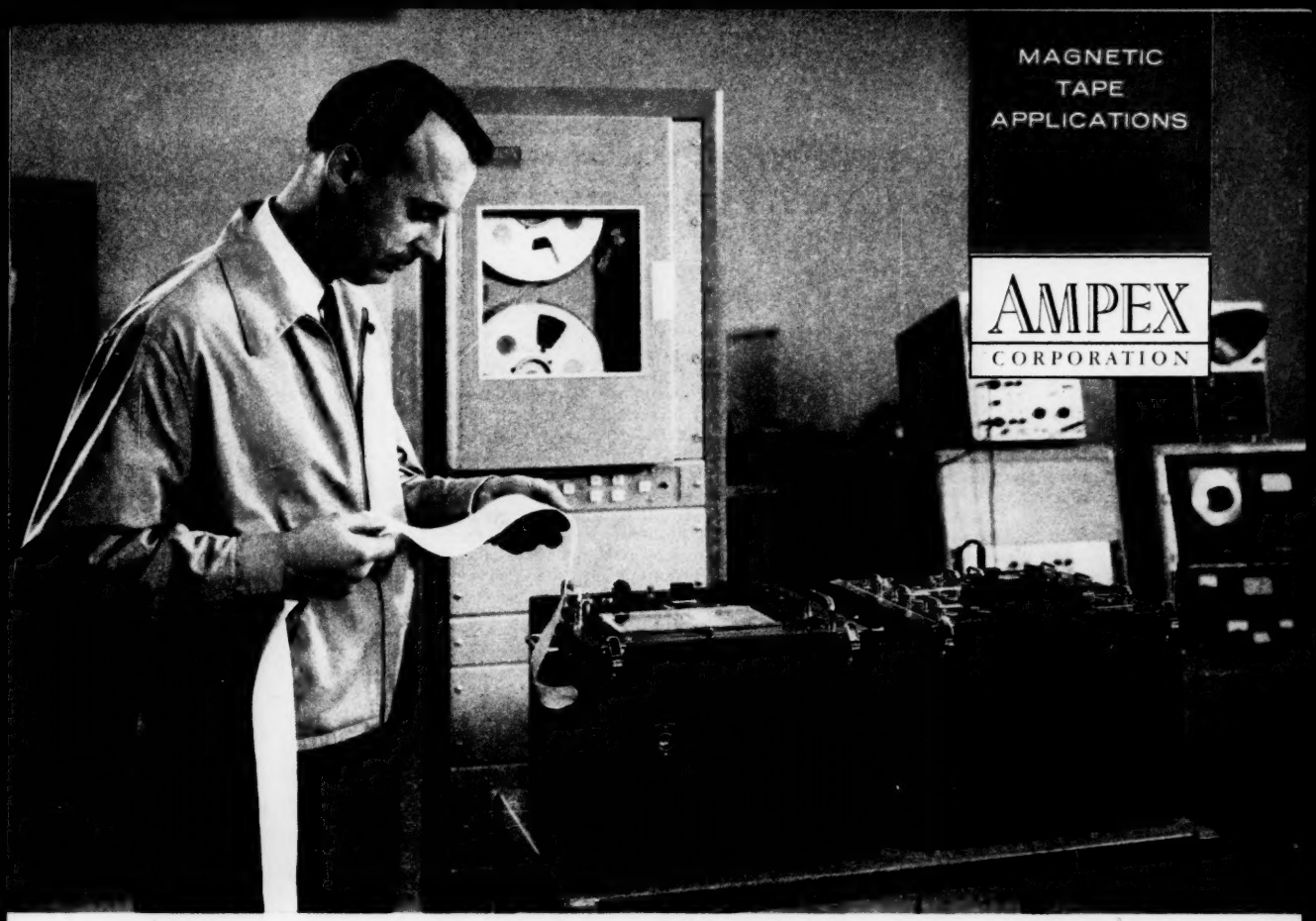
2. International technical groups can serve to standardize terminology and to increase international unity.

3. Reading habits of French technical personnel are similar to those of Americans—terrible. Average French engineer spends only about $10 of his own money on technical books per year, depending on his company to buy his books.

4. Technical material published in French suffers from same defects as in America—too many shallow sensational give-away publications at one extreme, with too highly technical material that can be understood only by a few at the other extreme.

5. Number of years of study leading to a technical degree in France is about the same as in the USA, but the French curriculum is considered heavier and more difficult.

6. School facilities are inadequate in France—and there are many more registrants for technical universities



How to write 10,000-cycle data on a pen recorder

A tape tie-in banishes frequency-response limitations and saves paper

We will cancel the laws of physics, throw out inertia, and behold here is a pen recorder writing out 10,000 cycles per second ready to read. Don't scoff. There is a way. Assuming visual data is really what you want, keep your eye on the oscillograph or pen recorder, and think of the tape recorder as an ingenious "frequency-response extender" or "data stretcher."

A SLOW-MOTION LOOK AT TRANSIENTS

When an aircraft manufacturer was having shock problems from the firing of an experimental plane's armament, nothing could be seen in real-time data. For a better look, shock waves were recorded on tape, slowed down, recopied and then written out in visual traces. A thousandth of a second was stretched out to a full second. The exact extent and nature of the shock pattern and its manner of transmittal through the plane's structure became clearly evident – and with it the design solution.

100-TO-1 DATA STRETCHOUT (and more)

Compared to any visual-trace recorder, an Ampex instrumentation tape recorder has virtually unlimited response. Frequency components as high as 10,000 cycles per second (and much more) are easily recorded. And tape has decided advantages too at 1000 or 2000 cycles. A tape speed of 60 inches per second captures any of these higher frequencies and has tremendous room for slowdown on playback. Reproducing the tape at 0.6 in/sec. reduces 10,000 cps. to a mere 100. Connect a direct-writing recorder to the tape recorder and 100 cycles response is all that you need.

Actually Ampex has a wide range of tape speeds and tape slowdown ratios available. Tapes can be recopied once or even twice multiplying these ratios accordingly.

TYPICAL TAPE SLOWDOWN (OR SPEEDUP) RATIOS

AMPEX MODEL	Basic speed ratio	First recopy	Second recopy
FR-1100	8 to 1	64 to 1	512 to 1
FR-100	32 to 1	1024 to 1	32,768 to 1
FR-1100 multirange (many versions available)	100 to 1	10,000 to 1	1,000,000 to 1

24 TIMES AS MUCH RECORDING TIME

On 5000-cycle data, an ordinary 10½" reel of 1-mil magnetic tape will record 24 minutes. On a visual-trace recorder writing 100 cycles per inch, a 250-foot magazine of expensive paper would last just one minute! When you record data first on tape, you will seldom recopy the whole test onto paper. With an oscilloscope or other scanning device, you find the important parts of the tape and copy as little as a few seconds onto the visual medium. The tape can be stored for future reference, cut into loops for analysis or can be erased and reused. It saves hundreds of feet of paper.

Because magnetic-tape data is an "electrical analog", it can also be used for automatic frequency analysis, computer input, simulation of phenomena and scanning, counting and correlating techniques. We have told the whole magnetic-tape story in a well illustrated and diagrammed 16-page brochure. For your copy, write Dept. BB-13.

AMPEX INSTRUMENTATION DIVISION • 934 CHARTER STREET • REDWOOD CITY, CALIFORNIA

Phone your Ampex data specialist for personal attention to your recording needs. Offices serve U. S. A. and Canada. Engineering representatives cover the free world.

For more information circle **16** on inquiry card.

Random, Complex and Sine Wave VIBRATION TESTING SYSTEMS

PROVE your product's reliability

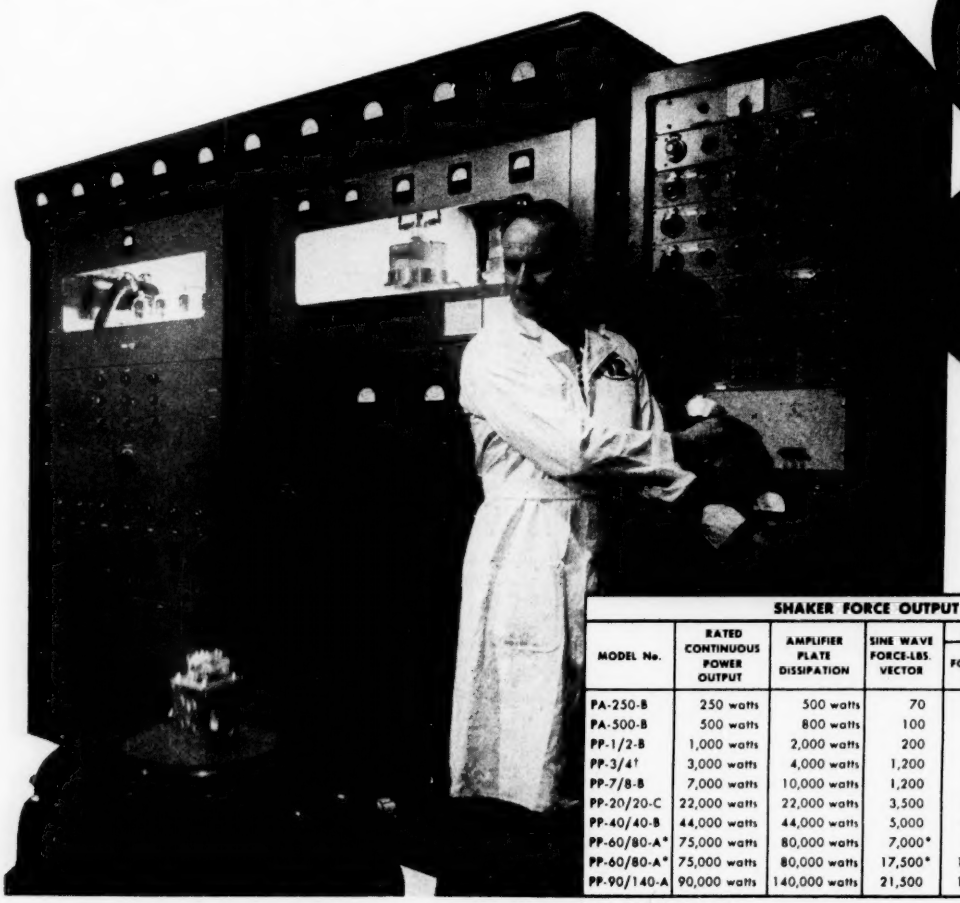
Whether you think of vibration testing as a means of prototype shake-down, or as a full quality control test on production runs, there's a Ling system for the job. Parts, components or even an entire missile, airplane or other major package can be tested to desired specifications with one of Ling's line of complete systems.

These systems include high-powered vibration generators with output ratings from 1 to 90 KVA, operating consoles, electro-mechanical shakers and accessory equipment as necessary for any specific test requirement.

Ling vibration systems are capable of producing a wide variety of tests, ranging from simple sine-wave sweeps to the exact reproduction of random or complex vibrations which are tape recorded from actual missile flights.

Among the new developments in high powered electronics by Ling is a packaged vibration test system—the Sine-O-Matic. This compact unit contains everything necessary for fully automatic or programmed sine wave testing in a single, desk-type console. Only the shaker is separate.

Another example of Ling's leadership is a complete mobile testing laboratory capable of field testing an entire airplane, missile or any large component. Ling sales engineers will be happy to discuss your own vibration testing requirements, whether for a standard system or in solving advanced vibration test problems.



This 20 KVA power generator and control console at Rocketdyne is one of 23 complete Ling systems at North American Aviation Divisions.

SHAKER FORCE OUTPUT						
MODEL No.	RATED CONTINUOUS POWER OUTPUT	AMPLIFIER PLATE DISSIPATION	SINE WAVE FORCE-LBS. VECTOR	RANDOM NOISE		ARMATURE PROTECTOR MODEL REQUIRED
				FORCE-LBS. RMS	FORCE LBS. PEAK	
PA-250-B	250 watts	500 watts	70	—	—	—
PA-500-B	500 watts	800 watts	100	—	—	—
PP-1/2-B	1,000 watts	2,000 watts	200	—	—	—
PP-3/4†	3,000 watts	4,000 watts	1,200	—	—	—
PP-7/8-B	7,000 watts	10,000 watts	1,200	840	2,520	AP-10-A
PP-20/20-C	22,000 watts	22,000 watts	3,500	2,500	7,500	AP-30-A
PP-40/40-B	44,000 watts	44,000 watts	5,000	3,500	10,500	AP-40-A
PP-60/80-A*	75,000 watts	80,000 watts	7,000*	5,000*	15,000*	AP-60-A
PP-60/80-A*	75,000 watts	80,000 watts	17,500*	12,000*	36,000*	AP-60-A
PP-90/140-A	90,000 watts	140,000 watts	21,500	14,000	42,000	AP-60-A

*WITH APPROPRIATE SHAKER

LING ...leader in high-power electronics

ELECTRONICS INC.

9937 WEST JEFFERSON BOULEVARD • CULVER CITY, CALIFORNIA • TELEPHONE: TEXAS 0-7711

For more information circle **17** on inquiry card.

than can be accomodated. The French government issues all diplomas.

7. There are not enough technicians in France. State has created six diplomas at the technician level—electro, radio, refrigeration, market and business, and draftsman.

8. Teachers in France are like those in USA—underpaid.

9. Average size of newest French power installations of turbine type is about 120,000 kw—same as in USA.

10. France has 10.5-million kw installed power capacity for its 44 million people (0.24 kw/person). USA has about 0.7 kw/person.

11. Since France has one large government-owned power system it does not have the tie-line problems that we have, but is considering economic dispatch like the Ohio-Edison system. French factors of (1) large system plus (2) higher fuel costs point to more computer usage.

12. Discovery of a "huge" deposit of gas in the Pyrenees, plus French use of coal for home heating, make possible turbine generators with gas fuel. Nuclear power is a long way off.

13. French use pneumatic control almost exclusively in power plants, and do not manufacture an electronic general-purpose control system. The new French Arjuzanx power plant will use a German (Hartmann & Braun) control system. Reason for picking H&B: Germans have experience with use of lignite fuel.

14. Regarding digital techniques, French do not manufacture analog-to-digital converters (or analog computers) but are very interested in data logging, tending to console-type centralized control systems.

15. French are interested in dogmatism of American control men—American proponents of electronic and pneumatic systems believe in their systems with a religious fervor.

16. Electrical control systems are only 15% more expensive than pneumatic systems in France, and the trend to electric systems is influenced by high cost of compressor installation and pneumatic tubing installation. Plastic tubing is apparently not generally used in France.

17. Instrumentation in the power plant is in a department reporting to the plant director. This department has an engineer in charge of "technical analysis"—and although he uses mathematics in his analysis, simulation by analog computer is not an established technique.

The Frenchmen who participated included: Michel Eugene Racine, Engineer, Test. Dept., Electricité de France; Arthur Jean Tamise, Head, Operation Dept. (Oise), Electricité de France; Jean Tixier, Chief Assistant, Technical Dept. (Lille), Electricité de France; Marcel Paul Verneau, Chief, Design Dept., Compagnie Générale d'Entreprises Electriques; Maurice Eugene Wilfart, Engineer, Société Générale de Constructions Electriques et Mécaniques "Alsthom."

News Bit

ELECTRODATA DIV. of Burroughs is supplying its Type 205 general-purpose digital computers to the University of Utah and the University of Denver.

INSTRUMENT ENGINEERS . . .

here's a money-saving tip on small valves

You can stop worrying about heavy-handed operators ruining the stem points and seats on your small valves when you install Hoke's new 270 Series bar stock valves with plastic pointed stems. Let them "tighten down" all they want, because these long-wearing nylon or corrosion-resistant Kel-F tips have taken 700 cycles of operation at 3500 psi using twice the normal closing force—and the valve did not leak across the seat. They'll save you money three ways—cutting valve replacement, down-time and maintenance.

Use this new Hoke valve for vapor or vacuum leak-tight closure, in service up to 5000 psi. It also minimizes opening pressure surges, and meets applicable MIL specs for use on high pressure compressors. Available in ⅛" or ¼" sizes, globe or angle pattern, with O-ring or Teflon packing. All valves can be panel-mounted.

Complete information is yours on request. Write us today.

Why buy big when you can buy Small

HOKE

HOKE INCORPORATED
FLUID CONTROL SPECIALISTS
231 South Dean Street
Englewood, New Jersey

For more information circle **18** on inquiry card.

Easy does it

when you laminate plastic

with the help of

a Fenwal 541 Temperature Indicating Controller

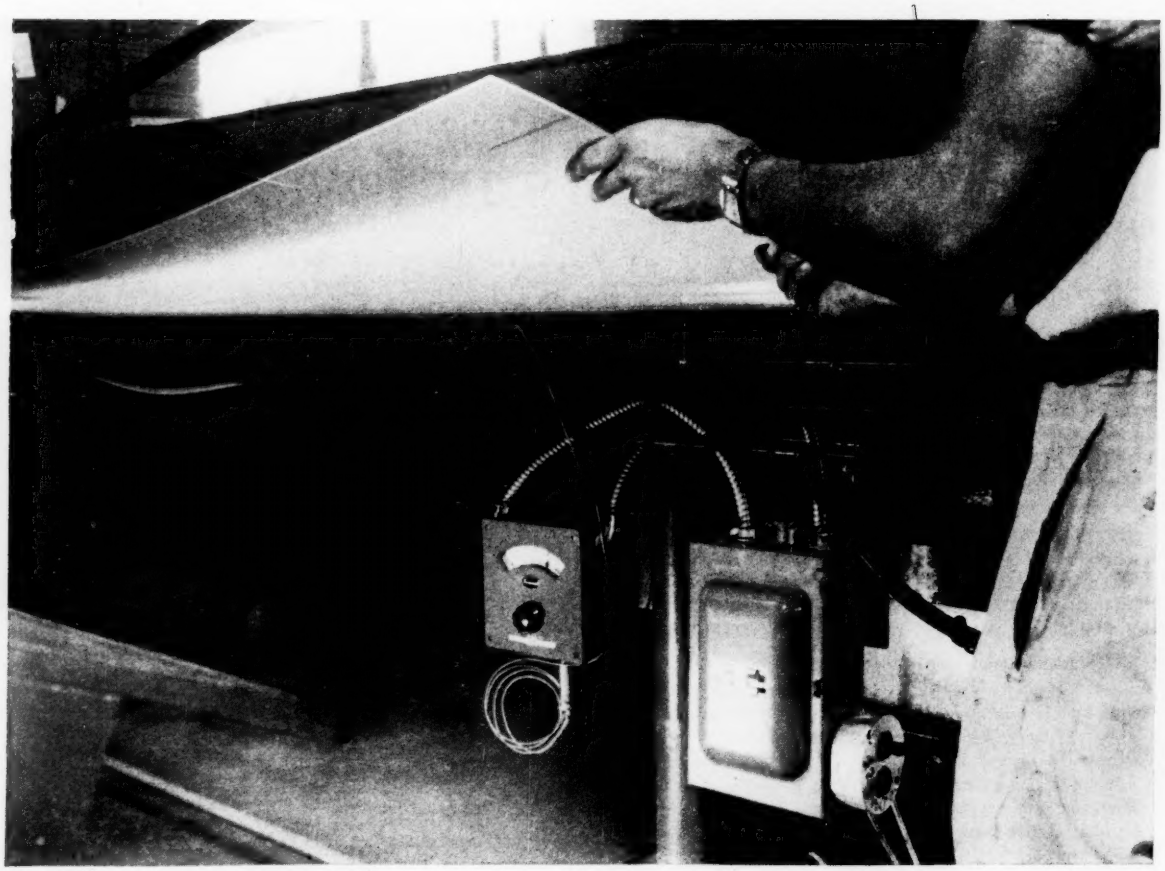
Whether you postform laminated plastic (the machine here is heating a seamless phenolic plastic counter top), or rely on temperature indicating controllers for any of a thousand other reasons, *Fenwal's 541 is the easiest to operate!*

The 541 has a host of long life features — corrosion proof 316 stainless steel, swivel mounted capillaries and bulbs . . . splash and dust proof housing. Self-compensating wear means continued accuracy with minimum maintenance. All components are accessible, easy to adjust. *It's simple and reliable!*

With ranges from −150° to +700°F., the 541 can accurately control one, two, or four circuits. Choose from several bulb and capillary styles, four basic models, variety of housing colors — hundreds of combinations to solve *your* temperature control problem. *It's versatile!*

Find out more about this Fenwal temperature indicating controller that is virtually custom-designed for you. Write to Fenwal Incorporated, 367 Pleasant Street, Ashland, Massachusetts, and ask for a catalog or a sales engineer.

Precise temperature controls on this laminating press make postforming thermoset plastics easy, quick, nearly automatic. This is our single circuit model (there are 575 others) with one SPDT switch and one control pointer. Housings on all Fenwal 541's meet NEMA and JIC specifications.



Fenwal CONTROLS TEMPERATURE . . . PRECISELY

For more information circle **19** on inquiry card.

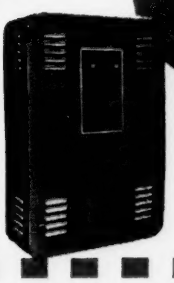
D. E. MAKEPEACE DIVISION

FOR UNLIMITED PLACEMENT

SLIP RING ASSEMBLIES . . . Performance closely approaches that of a uniform cable. Crosstalk between circuits similar to shielded cable; impedance match at video frequencies like matched coaxial cable, at radio frequencies sufficiently close for many applications. Contact and brush resistance usually less than lead resistance; noise negligible. Assemblies meet military requirements for shock, vibration, humidity, enclosure. All sizes 1 to 400 circuits. Excellent service at 0 to 30 kv and higher voltage, 0 to 600 amps and higher current, DC to 100 mc frequency, to 30,000 rpm speed. Small and lightweight.

D. E. Makepeace Division, Attleboro, Mass.

For more information on Slip Ring Assemblies circle **20** on inquiry card.



CHEMICAL DIVISION

FOR PURIFYING AND PURIDRYING

DEOXO® PURIFIER . . . provides low-cost catalytic purification of hydrogen and other gases to the extent of less than one part oxygen per million. Requires no operating expense, no maintenance, no reactivation, no auxiliary heating, no water cooler. DEOXO® DUAL PURIDRYER . . . combines continuously-operating, dual tower, automatically-run drying unit with the features of Deoxo Purifier—catalytically produces pure, dry hydrogen, so pure it contains less than one part oxygen per million, so dry that it has a dew point of better than —100° F.

Chemical Division, 113 Astor Street, Newark 2, N. J.

For more information on Deoxo Purifier circle **21** on inquiry card.

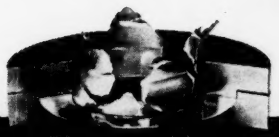
BAKER PLATINUM DIVISION

FOR PRESSURIZED APPARATUS

RUPTURE DISCS . . . discs of precious metals, resistant to most corrosive agents and unattacked under conditions that base metal discs could not withstand. Specific physical properties ensure bursting only at the predetermined pressure. Base metal discs also available.

Baker Platinum Division, 113 Astor Street, Newark 2, N. J.

For more information on Rupture Discs circle **22** on inquiry card.



ENGELHARD INDUSTRIES, INC.

113 ASTOR STREET
NEWARK 2, NEW JERSEY

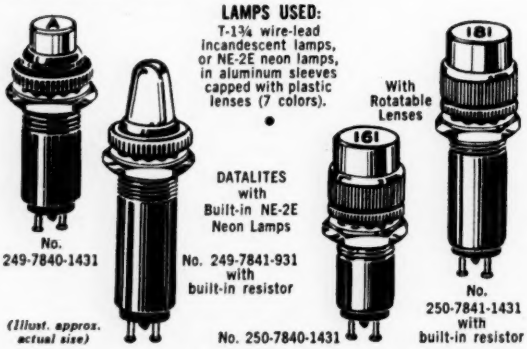
In this brochure—complete facts on DIALCO's

DATALITES®

For the Computer-Automation Industries

DATALITES by DIALCO are ultra-miniature Indicator Lights specially designed to meet the critical requirements of the computer-automation fields. Made in 2 basic styles: *Lamp Holders with* DIALCO'S own *replaceable Lamp Cartridges* (see above); or integrated DATALITES *with Built-in Neon Lamps* which are *not replaceable* (see below). Ultra-compact, single units mount in ⅜" clearance hole; the twin-lamp assembly mounts in ¾" clearance hole.

LAMPS USED:
T-1¾ wire-lead incandescent lamps, or NE-2E neon lamps, in aluminum sleeves capped with plastic lenses (7 colors).



DATALITES have fully insulated terminals and conform to all applicable military specifications. Integrated units are available *with or without built-in resistors.* The cylindrical lenses can be hot-stamped with digits, letters, etc. Complete details in *Brochure L-160.* Send for it now.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Foremost Manufacturer of Pilot Lights

DIALIGHT CORPORATION

42 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600

For more information circle **23** on inquiry card.

stock report

Any further information concerning any of the following issues may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

American Stock Exchange: Price Range For 1958 Thru 6/16/58

	High	Low	Price as of 6/16/58
American Meter	35 3/8	27 5/8	34 3/4
Arc Equipment	18 1/2	13 3/4	18
Barry Controls "B"	8 1/2	4 3/8	7 - 7 5/8 (1)
Belock Instruments	10 1/8	7 3/8	9
Benrus Watch	6 7/8	4 7/8	5
Breeze Corp.	6 1/2	5 1/4	5 5/8
Clark Controller	17 7/8	14 7/8	16 1/2 - 16 3/4 (1)
Clarostat Mfg.	3 3/4	2 7/8	3 1/4
Clary Corp.	4 3/4	2 7/8	3 7/8
DuMont Laboratories	5 5/8	3	4 1/8
Dynamics Corp. of America	4 1/8	2 7/8	3 5/8
Electronics Corp. of America	7 7/8	6 3/8	7 1/2 - 7 5/8 (1)
El-Tronics	3 1/8	1 5/8	2 1/8
Fairchild Camera & Instrument	31 5/8	19 1/2	25 1/4
Globe-Union	17 1/4	14 5/8	15 3/4 - 16 1/2 (1)
Hazeltine Corp.	40 1/8	30 1/2	38 5/8
International Resistance	4 5/8	3 3/4	3 7/8
Lear, Inc.	7 1/8	4 1/4	6 1/2
National Research	16 3/8	12 7/8	15 1/2
Neptune Meter	23 7/8	19 1/2	23 1/2
New Haven Clock	3 1/4	7/8	1 1/8
Norden-Ketay	6 7/8	2 3/4	3
Nuclear Corp. of America "A"	2	1 3/8	1 3/4
Pneumatic Scale	26 1/4	18 1/2	25 - 26 (1)
Servo Corp. of America	6 3/4	3 3/4	6 1/2
Servomechanisms	9 1/2	6 5/8	9 1/2
Wallace & Tiernan	27 1/4	24	25
Waltham Prec. Instrument Co.	1 1/2	13/16	1

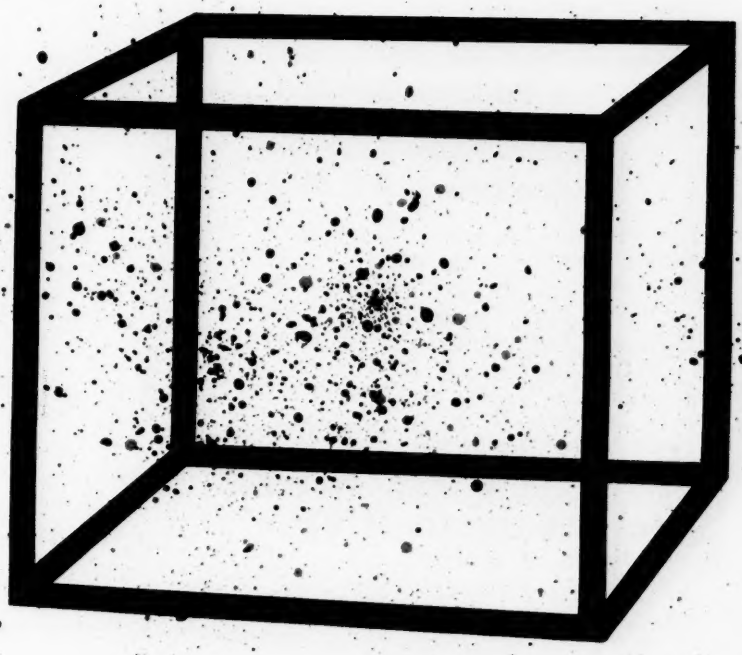
1) Not Traded-Bid, Asked

New York Stock Exchange: Price Range for 1958 Thru 6/16/58

	High	Low	Price As of 6/16/58
ACF Industries	45 1/2	37 3/4	39 7/8
Aeroquip Corp.	21 7/8	16 7/8	18 5/8
Allis Chalmers	26 3/4	22 1/8	23 7/8
American Chain & Cable	45 3/4	39 1/2	43 1/2 - 44 1/4 (1)
American Machine & Foundry	37 7/8	32 1/4	34 1/4
American Machine & Metals	57 1/2	47 1/2	52 3/4
American Optical	39 1/8	36	36 7/8
American Tel. & Tel.	179 1/2	167 7/8	179 3/8
Beckman Instruments	25 3/4	18 1/8	20
Bell & Howell	65 3/8	42	61
Bendix Aviation	55	44 1/2	54 3/4
Boeing Airplane	44 5/8	34 1/8	43 7/8
Bullard	15 3/4	10	13 7/8
Bulova Watch	12 5/8	9 3/4	11 3/8
Burroughs	36 1/2	27 5/8	36 1/8
Carborundum	35 7/8	30 7/8	34 3/4
Cincinnati Milling Machine	37	27	34 7/8
Clevite	18 3/8	15 3/4	17 1/8
Columbia Broadcasting "A"	32	24 1/2	31 1/8
Consolidated Electrodynamics	35 1/4	27 7/8	29 3/4
Consolidated Electronics	26 3/4	19 1/2	24 1/4
Cornel Dubilier	16 1/2	12 3/4	15 7/8
Corning Glass	86 3/4	74 5/8	85
Curtiss-Wright	28 1/8	20 5/8	25 3/8
Cutler Hammer	50 7/8	40 1/2	47 5/8
Daystrom	36 1/4	30	36 1/4
Douglas Aircraft	74 7/8	54 1/2	57 5/8
Eastman Kodak	111 1/4	97 1/8	111
Eaton Manufacturing	46 1/2	38 1/2	46 1/2
Electric Auto Lite	31 7/8	25	29 3/4
Elgin Watch	9 3/4	6 3/4	7 3/4
Emerson Electric	38 1/4	29	38
Food Machinery & Chemical	57	47 1/2	56 1/2
Gamewell	26 3/4	20 1/2	26 1/4
Garrett	40 1/4	27	37 1/2
General Dynamics	65 3/4	55	58 3/8
General Electric	64 1/4	57	60 5/8
General Instrument	9 3/8	4 5/8	8 3/4
General Mills	77 1/4	60 1/4	73 1/2
General Precision Equipment	41	28 1/2	33 5/8
General Railway Signal	29 7/8	21 1/8	29 1/2
General Telephone	49	40 3/8	48 3/4
General Tire	21 7/8	16 5/8	21 1/2
General Tire & Rubber	30	22 1/4	24 7/8
International Bus. Machines	365 1/4	300	364 1/8

Continued on page 1146

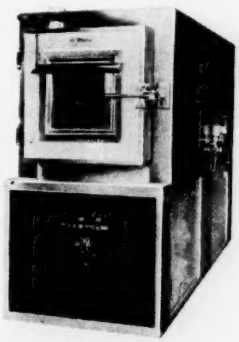
Please allow 4 to 6 weeks for change of address.



TENNEY packages any environment

...and delivers on time!

The most extreme field conditions your product will ever meet—duplicated exactly in a compact, precise Tenney environmental testing chamber custom-built for the job! Starting with one of Tenney's extensively-tested chamber prototypes, the right unit can be engineered in a surprisingly short time. In operation, actual environmental conditions are achieved quickly, maintained efficiently throughout the test run, and accurate data is provided for quick, simple evaluation. For literature describing Tenney's prototype chambers, or for recommendations on specific environmental testing problems, write to Tenney Engineering, the world's largest, most experienced creator of environmental testing equipment.



TENNEY ENGINEERING INC. USA

Tenney
ENGINEERING, INC.
1090 SPRINGFIELD ROAD, UNION, N. J.

PLANTS: UNION, N. J. AND BALTIMORE, MD. • THERE IS A TENNEY CHAMBER TO SIMULATE ALTITUDE, HEAT, COLD, HUMIDITY, VACUUM, EXPLOSION, SAND, DUST, FOG, AND MOST OTHER ENVIRONMENTAL CONDITIONS.

For more information circle **24** on inquiry card.

MARSHALLTOWN

THE RIGHT GAUGE FOR YOUR SPECIFIC NEEDS

Available in a wide variety of general purpose and special purpose gauges in pressure ranges to meet your specifications in every particular.

- PRESSURE
- VACUUM
- COMPOUND
- ALTITUDE
- COMBINATION
- DIAPHRAGM
- HYDRAULIC
- AND SPECIAL PURPOSE GAUGES
- DIAL THERMOMETERS (Vapor Tension or Bi-Metal)

WRITE TODAY FOR COMPLETE INFORMATION

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

For more information circle **25** on inquiry card.

GREEN ENGRAVERS *are fast!*

- Spindle speeds up to 26,000 rpm to engrave or for machining modern materials
- Fastest possible copy set-up
- Greatest ease and speed of adjustments
- Cutter grinders, rotary tables, master letters, compound slides, name plate blanks and all required accessories

MODEL D2 HEAVY-DUTY 2-DIMENSIONAL

- 575 pounds-rigid, sturdy, precise
- Vertical adjustment of copy table automatic with Pantograph
- Unobstructed on three sides to take large work
- Vertical range over 10 inches
- Micrometer adjustment for depth of cut
- Ball bearing construction throughout — super precision ball bearings in spindle
- Ratios 2 to 1 to infinity — master copy area 26" x 10"

MODEL 106 PORTABLE BENCH MODEL- 2- OR 3-DIMENSIONAL

- 40 pounds of unbeatable speed and accuracy at a reasonable price
- Perfect for all machining applications within its range
- Ball bearing spindle has three speeds up to 14,000 rpm
- 5 positive, accurate pantograph ratios
- One copy carrier (supplied) accepts all master sizes
- Height of pantograph and position of cutter are continuously adjustable
- Work up to 10" by any width
- Taper shank cutters

GREEN INSTRUMENT CO., INC.
383 Putnam Avenue Cambridge, Mass.

For more information circle **26** on inquiry card.

New York Stock Exchange: *Continued from page* 1141

International Tel. & Tel.	37 5/8	29 1/4	37 3/8
ITE Circuit Breaker	41 1/2	36 1/8	38
Litton Industries	51 7/8	36 7/8	51 1/2
Lockheed Aircraft	48 1/4	38 3/8	47 1/2
Magnavox	37 1/2	30 1/4	37 1/4
Mallory	28 3/4	23 5/8	26 1/4
Minneapolis-Honeywell	92 1/4	76	92
Minneapolis Mining & Mfg.	83	73 1/2	80 7/8
Motorola	42 1/4	35	40 5/8
National Acme	53 1/2	43 7/8	49 1/2
National Cash Register	71 1/2	50 1/2	70 1/2
North American Aviation	33 1/8	25 5/8	31 1/4
Northrop Aircraft	25 3/4	22 1/8	24 5/8
Otis Elevator	56	40 1/4	51 3/4
Philco	17 1/8	12 3/8	15 1/8
Radio Corp. of America	36 3/8	30 1/4	36 1/4
Raytheon	31 1/2	21 1/2	31 1/2
Reliance Electric	35	31	34 3/8
Rheem Mfg.	14 1/4	10 1/2	14 1/8
Robertshaw-Fulton	26 3/8	22 1/4	25 3/8
Royal-McBee	21	16	18
Sangamo Electric	34 3/4	25 7/8	27
Sperry Rand	20 5/8	17 1/4	18 5/8
Square D	24 5/8	20 1/8	22 3/8
Standard Coil Products	8 5/8	6	8 1/8
Starrett (L.S)	74 3/4	57	70
Stewart-Warner	34 3/8	29	33 7/8
Sylvania Electric	37 1/2	31 1/2	35 3/4
Telautograph	7	3 3/4	6 1/8
Texas Instruments	38 1/4	26 3/4	38 1/4
Thompson Products	55 1/4	41 3/8	47 5/8
Tung-Sol Electric	26 7/8	23 1/4	25 1/2
Underwood Corp.	22	12 7/8	19 1/4
Union Carbide Corp.	98	83 7/8	90
United Shoe Machinery	44 7/8	32	44 3/8
Western Union	20 1/2	15	20 1/2
Westinghouse Air Brake	22 7/8	17 7/8	22 3/4
Westinghouse Electric	65 1/2	56 1/2	57
Worthington Corp.	57	45 1/4	56 5/8

1) Not Traded - Bid and asked

Over-The-Counter

	Quotation as of 6/16/58 Bid	Asked
Aerovox Corp.	4 3/8	5
Aircraft Radio Corp.	18 1/4	19 1/2
Argus Corp.	21	21 5/8
Eitel-McCullough	26 1/4	27 1/4
Electronics Associates	39 3/4	41 1/2
Erie Resistor Corp.	6	6 3/8
Fisher Governor Company	13 5/8	14 1/8
G.M.Giannini	13 7/8	14 3/4
Industro Transistor	1 1/4	2
Liquidometer Corp.	6	6 1/2
W.L.Maxson	6 3/4	7 3/8
Penn Controls, Inc.	14	14 3/4
Speer Carbon, Inc.	22 1/2	23 1/4
Sprague Electric	29 1/2	31
Taylor Instrument	28	29 1/4
Telecomputing Corp.	4	4 3/8
Topp Industries	9 1/8	9 3/4
Varian Associates	18 3/4	19 1/4
Vitro Corp. of America	15 5/8	16 3/8

Electronic Circuitry for Instruments and Equipment

by MILTON H. ARONSON
Editor,
Instruments & Automation

◆

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A complete home-study TEXT and COURSE, with 458 multiple-choice home-study test items on basic electronic circuitry for instruments, communications, TV, laboratory apparatus, and military equipment.

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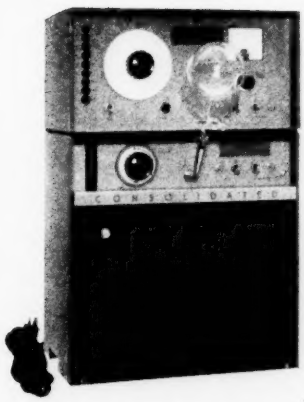


quick, accurate gas analyses

with low-cost, easy-to-operate,

analytical **mass spectrometer**

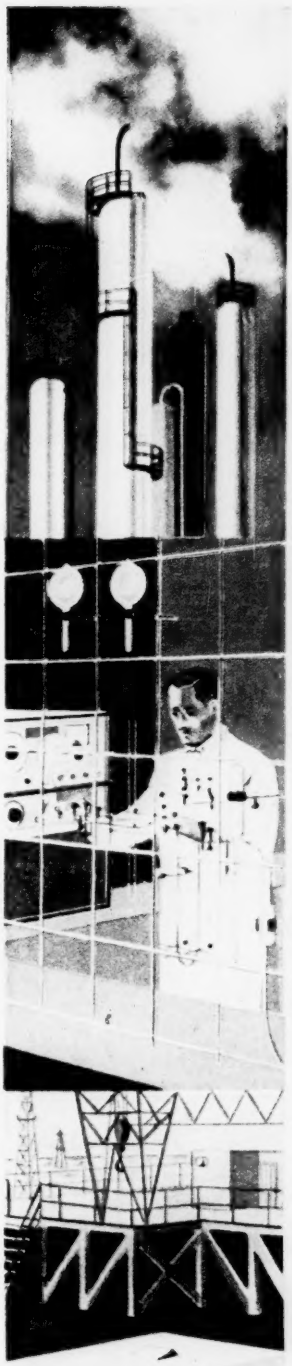
available for batch or continuous analysis

This easy-to-operate analytical instrument provides high sensitivity at low cost . . . with unusual portability that enables industrial engineers and research scientists to improve quality control and analytical service in plant, laboratory, or field applications.

The 21-611 features rugged, modular construction . . . weighs only 115 pounds. Easy to install in a trailer, on a bench, or in a plant, where its separate vacuum module may be stacked with or operated apart from its electronic module. Highly dependable and stable, the 21-611 operates with exceptional reproducibility in the mass range from 2 to 80 with resolving power adequate for separation of adjacent peaks up to mass 32. A unique scanning dial eliminates mass marking, and a new, metal rotary valve makes batch sample introduction a routine operation —even for inexperienced personnel.

The 21-611 analyzes individual samples as small as 0.1 standard cc of gas or 0.001 cc of liquid. Complete analysis takes less than a half hour, while measurement of single components can be made in a matter of minutes. As a process monitor in the plant proper, the 21-611 samples directly from the process stream or atmosphere. It instantly reflects deviations from optimum operation, provides analyses that improve process control and result in better product quality and yield.

For complete information, call your nearby CEC sales and service office, or write for Bulletin CEC 1843A-X12.



Typical applications of the 21-611 in batch and continuous analyses

• Analysis of light hydrocarbons and fixed gases • Breath analysis in medical research • Monitoring furnace atmospheres in metallurgical work • Stack gas analysis in power plants • L. P. G. analysis • Checking ratio concentrations in ammonia manufacture • Synthesis gas monitoring in petrochemical plants • Monitoring light hydrocarbon gases of return mud streams from oil wells during drilling operations.

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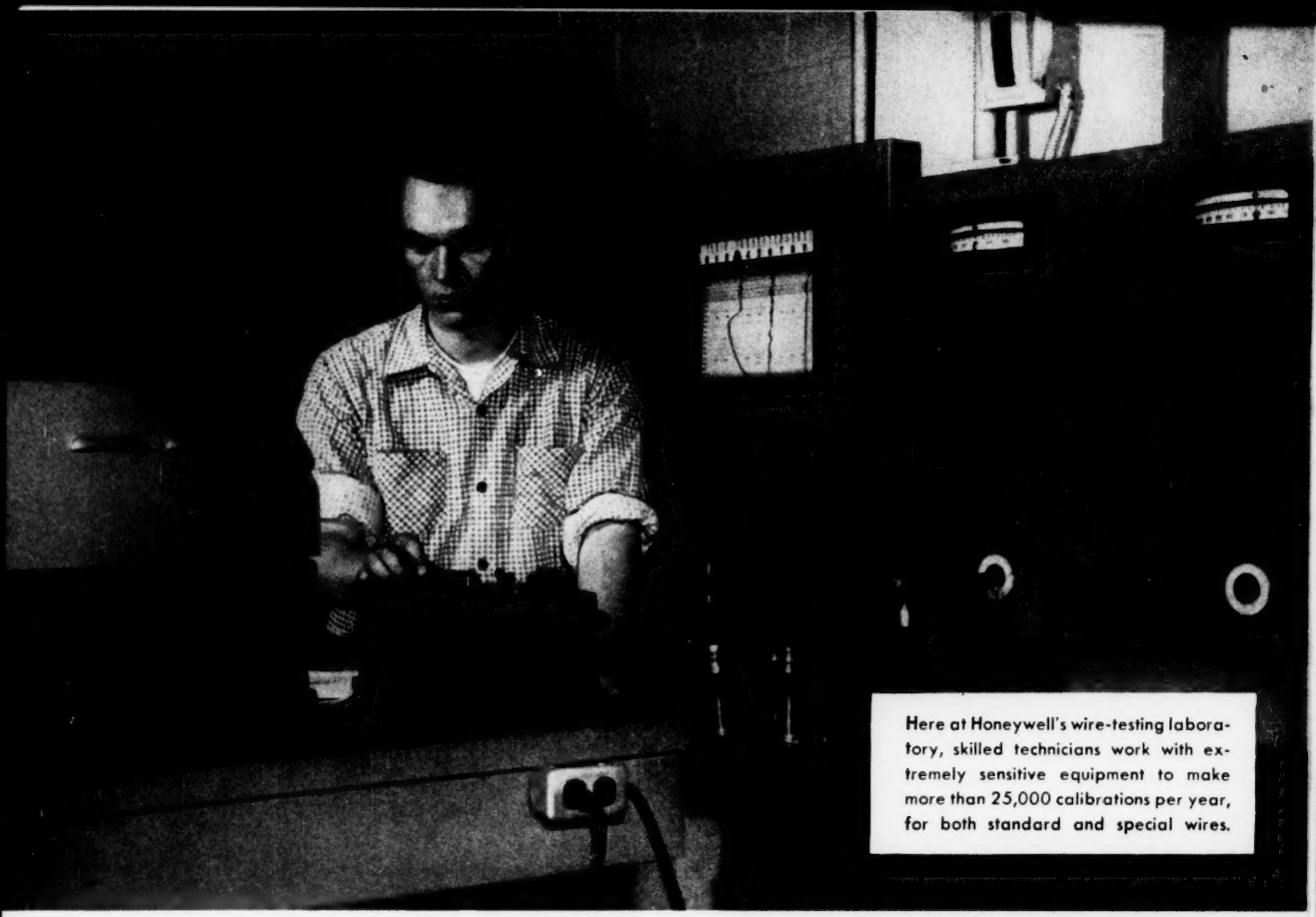

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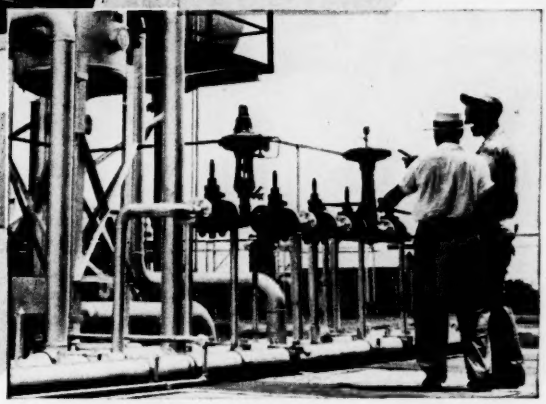

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1. **Sales Engineering:** BS&B Sales Engineers and Representatives are strategically located throughout the United States, Canada and Latin America to assist you with specifications, operation and maintenance problems involving BS&B Controls.

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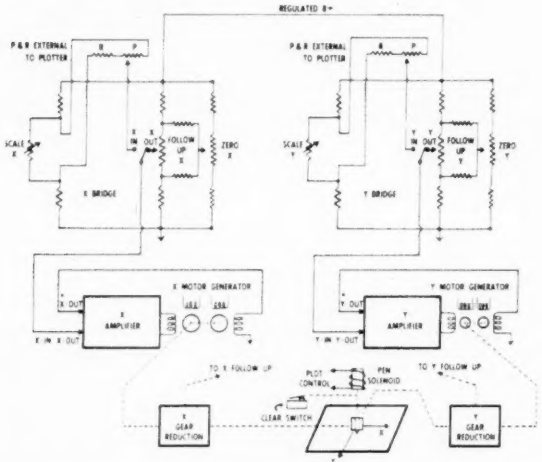
For more information circle **28** on inquiry card.

briefs

X-Y Plotter and Recorder

The 200A X-Y Plotter responds to analog or digital inputs transduced by two potentiometers or comparable voltage-dividing devices located externally. The resistance presented by these voltage dividers completes modified Wheatstone bridge circuitry associated with each plotter axis . . .



The Model 200B X-Y Plotter accepts DC voltage as its inputs and contains a regulated follow-up power supply. This supply is referenced to an Eppley Standard Cell and is chopper stabilized to eliminate adjustment and provide drift-free operation . . . Input sensivity for the millivolt ranges is varied by changing the voltage gradient from the follow-up potentiometers and an input attenuator is introduced only on the one volt and higher ranges . . . (*From new 8-page catalog. Librascope, Inc., 303 Western Ave., Glendale, Calif.*)

For this literature circle **201** on inquiry card.

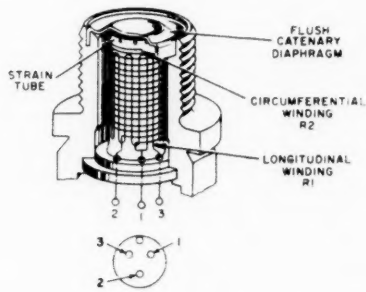
Why Use A Magnetic Strain Gage?

The electromagnetic type of strain gage is especially suited to making strain measurements for the following reasons: (1) The power output is large enough to drive a conventional high-torque instrument without the use of an amplifier. (2) A high magnification (ratio of instrument-pointer movement to strain) is easily obtained. (3) The indicating instrument may be located approximately 100 feet from the strain gage. (4) Warning signals can easily be employed. A contact-making instrument may be used to flash a light or ring a bell at a predetermined value of strain . . . (5) Slow-changing strains (maximum, 5 cycles per second) can be recorded by suitable recording instrument . . . (*From new 4-page Bulletin GEC-888A, General Electric Company, Schenectady 5, N. Y.*)

For this literature circle **202** on inquiry card.

Pressure Transducers

Pressure fluctuations are received by the flush catenary diaphragm . . . Pressure on the diaphragm compresses a sensitive strain tube which supports and prestresses the center of the diaphragm. As pressure



increases, this slender, cylindrical tube decreases in length and increases in diameter. The dimensional change is detected instantly by two wire strain gages bonded directly on the strain tube . . . These two bonded windings form adjacent arms of a bridge—the unbalance caused by a change in pressure is proportional to the applied pressure . . . Small mass and minute deflection of the diaphragm-strain tube assembly result in excellent frequency response (within ±1 db from 0-20,000 cps.)—(*From new 4-page Bulletin A-257, Norwood Controls, Unit of Detroit Controls Corp., 934 Washington St., Norwood, Mass.*)

For this literature circle **203** on inquiry card.

Palmer Epoxits

Adhesion of Palmer 7078 Resin is unsurpassed if reasonable preparations prior to application are followed . . . Curing time at 150°F is 20 minutes and at 78°F approximately two hours . . . Linear expansion is excellent . . . which makes this application ideal for protection of all copper circulating lines exposed to expansion and contraction . . . highly recommended also for fresh water tanks, cargo tanks, eatable oils, etc. . . Pot Life: Mixed 7078 features long pot life for practical application. 5 or more gallons may be mixed . . . pot life in excess of 8 hours at 75°F . . . Cure or Hardening: Tack free 4-6 hours at 75°F. Coating may be force dried for 20 min. at 200° or 1½ hours at 140°F . . .

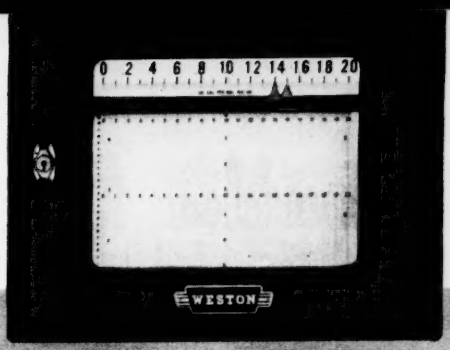
Palmer 7079 Epoxit is a clear or colored, syrup-like, liquid resin. It is a single part system not requiring addition of hardener. Recommended for corrosion and chemical protection on surfaces from 250°F to 425°F.

#6003-A is a semi-white, very thixotropic, fast epoxy resin, recommended for forming fillets, radii, splining, filling holes and cracks, and as a high strength adhesive for metal, wood and plastic. It is only slightly less thixotropic than conventional glass putty, but cures hard and is free machining . . . (*From ten-new leaflets on Palmer Epoxits, Port Service Corp., 601 Degraw St., Brooklyn 17, N. Y.*)

For this literature circle **204** on inquiry card.

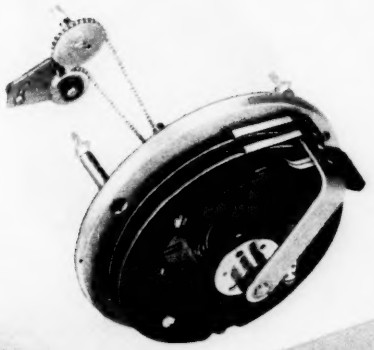
Continuous, dependable automatic control . . .
with the

DAYSTROM-WESTON
RECORDER-CONTROLLER



UNITIZED* design

features relays that never break!



***UNITIZATION:**

the grouping of related components — in Daystrom-Weston Potentiometer Recorders — in the simplest, most serviceable, most efficient manner.

DAYSTROM-WESTON'S basic potentiometer instrument design is supplemented by an exclusive control mechanism in the recorder-controller version. By using a minimum of parts—and keeping them compact, yet easily accessible—the advantages of DAYSTROM-WESTON UNITIZATION are brought to this controlling instrument. The results: an extra dividend in reliability and simple efficiency . . . in the most compact recorder-controller offering guaranteed ¼% accuracy.

Control settings are quickly and accurately made. Maintenance is simplified by the integration and interchangeability of key parts. And the control circuit offers unequalled sensitivity and dependability. Live circuits are NEVER BROKEN . . . they are ALWAYS MADE! The circular track contacts—with patented tumbler switch and gap design—permit response adjustments down to zero differential. A single screw makes the change. Proportioning control—as well as on-off control—is available in the standard instrument.

You see at left, details of the unitized control panel . . . including the exclusive contact-switching unit. In most other respects, this instrument is identical in construction, and offers the same advanced performance and maintenance features as the DAYSTROM-WESTON SINGLE-POINT and MULTI-POINT RECORDING POTENTIOMETERS.

For full information on any of these instruments, call your local WESTON Representative, or write to WESTON Instruments, Division of Daystrom, Inc., Newark 12, N. J. In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 10, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.

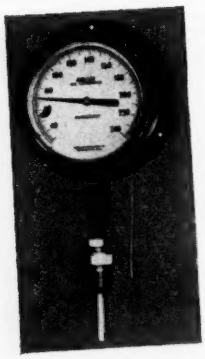
DAYSTROM-WESTON

A DAYSTROM UNIT

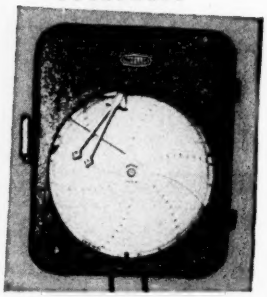
Industrial Instruments

For more information circle **29** on inquiry card.

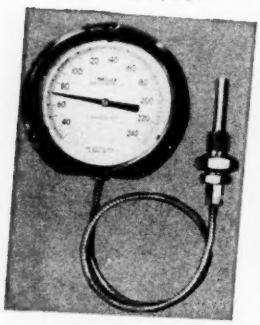
You get dependability PLUS with Moeller dials and recorders



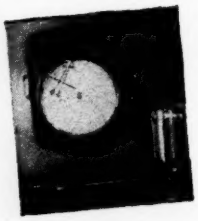
Adjustable Form Dial Indicating Thermometers with separable socket. Can be quickly adjusted to any angle.



Single and Multiple Pen, Remote Recording Thermometers. Available for one and two temperature recordings in round cases and up to four temperature recordings in rectangular cases.



Remote Reading Dial Thermometers. Mercury actuated, with separable socket. Panel or flush mounting.



Moeller Recording Psychrometer Type No. 6630 (wet and dry bulb temperature type) for accurate humidity determinations and records. Designed for rooms or apparatus where air circulation is poor.

...because our business is the design and manufacture of temperature measuring instruments—and has been since 1867.

Specify and install these guaranteed Moeller Products. *Mail the coupon, today, for full details!*

MOELLER INSTRUMENT COMPANY 132nd ST. and 89th AVE RICHMOND HILL 18 N. Y.

Representatives in Principal Cities

Gentlemen: Without obligation, please send me Moeller Catalog No. 150 on Dials and Recorders.

NAME .....

FIRM .....

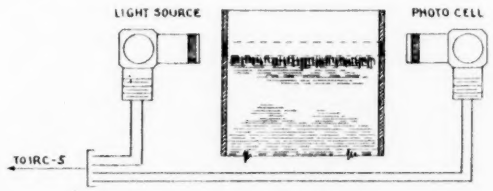
ADDRESS .....

CITY..... ZONE..... STATE.....

For more information circle **30** on inquiry card.

Miniaturized Electric Eyes

It is possible to pin-point light beams through apertures as small as 1/16". On larger apertures exact cut off may be had by observing the light pattern on a card and adjusting the cut off at any percentage of light by simply advancing card, etc. The percent-



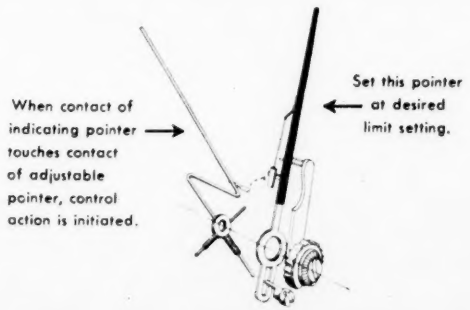
TANK LIQUID LEVEL ALARM

age of light can be accurately adjusted by regulating the light strength and sensitivity. To accomplish this there are two controls located in relay box . . . Relays: A double throw relay is furnished which will make or break control circuits. In special cases double pole, double throw relays can be provided. Current capacity 3 amps non-inductive load. For faster action—once each cycle—small loads up to 100 milliamperes, can be directly controlled from 2D221 Thyratron . . . (*From new 16-page Bulletin 571, Ess Instrument Co., 96 S. Washington Ave., Bergenfield, N. J.*)

For this literature circle **205** on inquiry card.

Tipp-Tronic Controls

Indication and primary control are provided by a contact meter-relay. A meter-relay is an indicating meter that is equipped with a second pointer which is adjustable to any point on the dial. When the moving pointer makes contact with the adjustable pointer, it closes a circuit that initiates control action


When contact of indicating pointer touches contact of adjustable pointer, control action is initiated.
Set this pointer at desired limit setting.

. . . The purpose of the contact meter is to sense, and furnish initial control only. An external DC power supply is required to operate the locking coil circuit built into the meter. Because of the nature of the meter contacts, it is inadvisable to use more than 25 milliamperes in the contact circuit. Therefore an external load relay must handle the usual contact requirements to provide control action. Tipp-Tron pyrometer, and electrical controls have indicating accuracy of 2%; control accuracy of 0.5% . . . (*From new 16-page Catalog AC-2, Tipptronic, Inc., Chagrin Falls, Ohio*)

For this literature circle **206** on inquiry card.

Circle 31 on inquiry card. ⟶

NOW the leaders in direct oscillographic recording offer you new standards in dynamic measurement with a *complete family* of

Honeywell Visicorders

featuring the *all-new*

Model 1012 36-channel direct recording

VISICORDER® OSCILLOGRAPH

designed from the base up to make fullest use of the completely proven and unsurpassed Visicorder principle pioneered by Honeywell.

H HONEYWELL

The dry and dustless direct-recording oscillograph that records without the use of powders, liquids, vapors, or other processing . . .

The new 36-Channel *Model 1012*

VISICORDER OSCILLOGRAPH

is the only direct-recording oscillograph . . .

* that provides a consistently accurate grid line system (amplitude reference coordinates). By recording longitudinal reference lines *simultaneously* with galvanometer traces and timing lines, the reference is always accurate, even if the paper should shift slightly during recording, or is susceptible to subsequent dimensional changes.
* that can be loaded and unloaded *in a matter of seconds,* in daylight, without separate magazines.
* that permits running the record backward, as well as forward, for closer study and analysis.
* that gives you a choice of 5 time lines intervals (.001, 0.01, 0.10, 1.00, 10.0 second) recorded by means of a flash tube, with provision for external synchronization. External signals applied simultaneously to galvanometers and timing system are in exact time relationship on the record.
* that offers complete push-button control of record speeds, without changing gears, in 15 steps from 0.1 to 160 in./sec., with automatic recording intensity control.
* that provides "center galvanometer" performance in all galvanometer positions.
* that utilizes hermetically sealed plug-in galvanometers that do *not* require dummies in unfilled positions, and that are completely interchangeable between various models (700C, 906A-1) because optical arms (11.8″) and, consequently, sensitivities are identical.
* that provides loading, operation and control from one surface.

. . . And these are just a few of its versatile features! The Model 1012 Visicorder is the most versatile instrument ever devised for converting dynamic data into immediately readable analog records. It has been specifically designed to make full utilization of the direct-recording Visicorder Principle that Honeywell pioneered and introduced with the Model 906 (see back cover). With the 1012, you can take records up to 200 feet in length with a wide selection of record speeds that provide maximum readability of the galvanometer traces even at the highest frequencies. You can record at frequencies from DC to 5000 cycles per second, at sensitivities identical to photographic-type oscillographs, and monitor the information as it goes on the record. The features of the Model 1012 give you conveniences never before possible in analog recording. Paper loading and unloading is quick and foolproof. A complete system of readily accessible controls, with indicator lamps, provides simple, positive control of recording. The 1012 records with or without longitudinal grid lines, as desired. Time lines may be varied through a choice of five ranges or not used at all; provisions for external timing are included. Galvanometer traces may overlap, with deflections as great as 8 inches peak-to-peak, and trace identification occurs on a 45° slope, interrupting galvanometer traces one at a time so that records are easy to read and analyze.

GENERAL FEATURES

FREQUENCIES & SENSITIVITIES
From DC to 5000 cycles per second without peaked amplifiers of any kind. Identical to photographic-type oscillographs.

RECORDING METHODS
Makes full use of the new Visicorder Principle. Records directly on paper which requires no powder magazines, liquids, vapors, or other processing. Daylight loading. Recording is accomplished in full view of the operator. Records are immediately visible and usable.

NUMBER OF CHANNELS
12, 24, or 36 active channels, as desired. Three magnet assemblies, each of which holds up to twelve ⅛″ Series M Honeywell galvanometers, plus two reference traces.

RECORDING WIDTH
12″ Visicorder paper (11⅜″ for active recording; ⅜″ margin for record numbering and event marking).

TRACE IDENTIFICATION
45° slope, interrupting galvanometer traces in sequence.

RECORDING SPEEDS
0.1 to 160 in./sec. Five speeds in each of 3 ranges (15 steps) via push-button control. No manual change of gears is required.

TIME LINES
Flash tube system. Choice of 5 intervals (.001, 0.01, 0.10, 1.00, 10.0 second) with each 10th line heavier. May be turned "off" or synchronized with external signals. With optical parallax being held to a minimum and negligible delay in initiating flash tube, timing lines and other data are recorded in exact time relationship.

RECORDING INTENSITY CONTROL
Proper aperture automatically established with record speed selection, or manually controlled as desired.

"NO RECORD" INDICATOR
Red indicator lamp and automatic shut-down of drive system indicates "No Record" if operator fails to turn on all necessary switches, if lamp fails, or if recording paper supply is exhausted. A separate lamp indicates when less than 25 feet of paper remains in supply.

PAPER LOADING
Simply done in a matter of seconds even by untrained personnel. All paper transport and take-up functions are integral. No separate magazines or other units required.

OTHER FEATURES
Automatic record length, adjustable 0-25′ (forward or reverse). Unused paper indicator. Paper knife. Push-button jump speed control. Record numbering system with provision for external actuation. Integral fluorescent light latensifier. Rack, table, or shock mounting. Provision for remote and/or multiplexed operation.

Time lines (every 10th line accented)

Trace identification

Longitudinal grid lines (every 5th line accented)

10-249 ← Record numbering

a representative record produced by the Model 1012 Visicorder. Note clear, accurate longitudinal grid lines, time lines, dynamic traces, and 45° sequential interruption of galvanometer traces for easy identification.

NEW MODELS OF THE *906* VISICORDER

The original 8-channel Model 906 Visicorder was the first successful oscillograph to break the barriers of frequency response and writing speed, and produce immediately readable records out to 2000 cps without the intervening steps of chemical processing.

Now the new Model 906A provides higher recording frequencies (DC to 3000 cps) and up to 14 channels of data. Factory-installed optional features and a wide variety of accessories are available as described at right. This means that you can select an instrument suited precisely to your requirements without price penalty for built-in or "special" features that may not be required.

The 906A Visicorder is provided in two models:

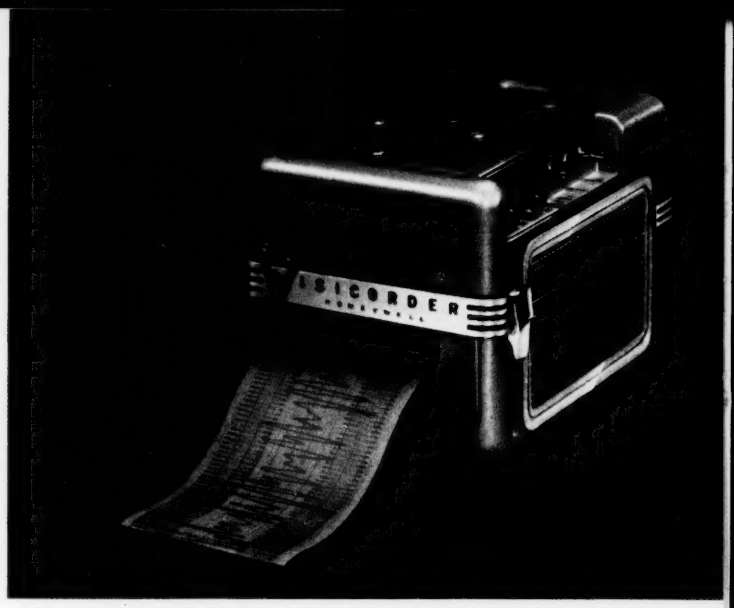
Model 906A-1 The basic instrument with high-sensitivity miniature plug-in galvanometers and magnet assembly. The use of subminiature galvanometers permits 14 simultaneous channels of data to be directly recorded at frequencies from DC to 3000 cps. These galvanometers are interchangeable in Honeywell-Heiland Model 906A-1, 708C, 712C, and 1012 oscillographs.

Model 906A-2 The basic instrument with "solid-frame" galvanometers and magnet bank from the original Model 906 Visicorder, providing for 8 channels of data to be directly recorded at frequencies from DC to 2000 cps. Galvanometers interchangeable in Model 906 Visicorder.

Reference Data: Write for Visicorder Bulletin
Minneapolis-Honeywell Regulator Co., Industrial Products Group, Heiland Division
5200 E. Evans Ave., Denver 22, Colo.

Honeywell

Heiland Division



Factory-installed optional equipment for both models includes:

Reducing collector lens to reduce static trace width to a minimum and concentrate maximum light source energy on galvanometers for normal writing speeds.

Standard collector lens to concentrate maximum light source energy on galvanometers for high writing speeds.

Recording intensity control to reduce spot intensity and record-trace breadth at low record travel and writing speeds.

Trace identification of the light-beam interruptor type for positive trace identification.

Grid line system—this exclusive feature provides longitudinal reference lines recorded simultaneously with data traces.

Timing unit provides timing pulses on .01, 0.1, or 1.0 second intervals.

Additional accessories for both models include:

Timing galvanometer provides maximum-density time lines (906A-1 only).

Record drive systems—your choice of 5 interchangeable systems, each covering 4 speeds.

Collector lenses (standard or reducing), recording intensity control, trace identifier, grid-line system (see above).

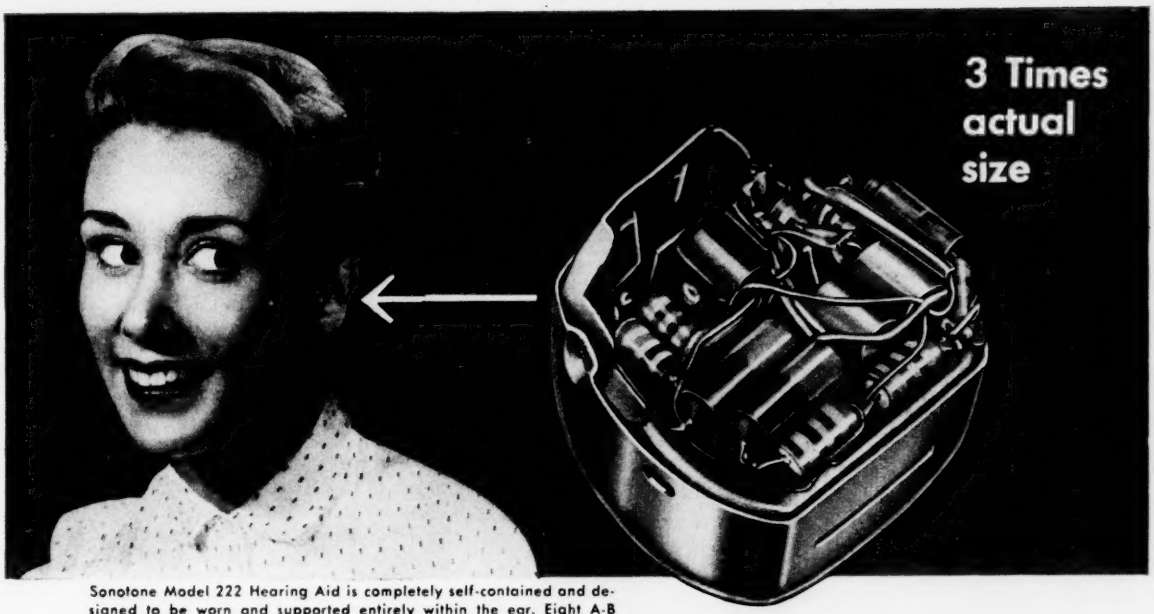
Relay rack adapters, bracket or gusset type.

Record takeup and latensifier to respool record paper after latensifying.

Record takeup unit to respool record paper.

USES OF THE VISICORDER

- ***In control*** for continually monitoring and recording reference and error signals.
- ***In nuclear applications*** to monitor and record temperatures, pressures, and other phenomena.
- ***In production test*** to provide a final dynamic inspection of electrical and mechanical devices.
- ***In computing*** to provide immediately-readable analog recordings.
- ***In pilot and component testing*** to accomplish more rapid evaluation of design and prototypes.
- ***In medical applications*** for dynamic blood pressures, electrocardiograms, and other physiological measurements.
- ***In all test applications*** which involve the assembly of considerable equipment and the gathering of personnel, the immediate Visicorder record will prove the success of the test at once before the test equipment is dispersed.



Sonotone Model 222 Hearing Aid is completely self-contained and designed to be worn and supported entirely within the ear. Eight A-B Type TR, 1/10-watt resistors are used in the three-transistor amplifier.

SPACE PROBLEM SOLVED

with ALLEN-BRADLEY Hot Molded Resistors

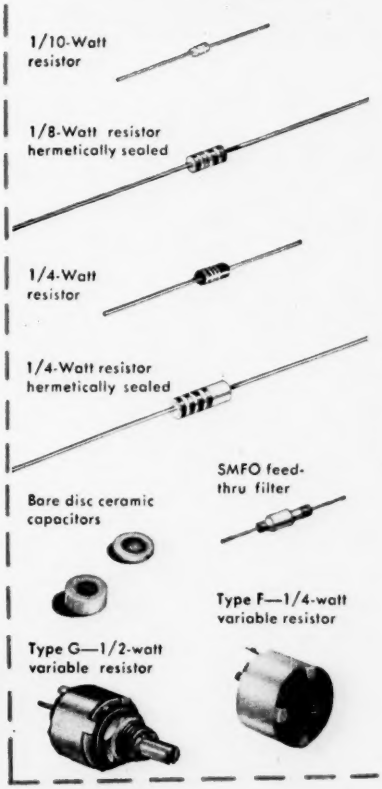
Your space problem may seem impossible, but—try Allen-Bradley Type TR resistors. You'll be able to trim space requirements *way* down . . . with *no* sacrifice in quality or reliability. These unbelievably small composition resistors are made by the same basic hot molding process as is used for the larger Allen-Bradley resistors . . . assuring complete freedom from catastrophic failures. The Type TR resistors have an insulating coating that will withstand a continuous maximum voltage of 200 volts d.c.

Where higher ratings are needed . . . and quality is important . . . it's still Allen-Bradley! These larger sizes have an insulating jacket that eliminates the need for impregnation . . . yet provides reliable protection against long periods of high humidity.

Allen-Bradley makes other space-saving components, too . . . including hermetically sealed resistors, variable resistors, capacitors, and filter elements . . . all built to Allen-Bradley's *quality* standards. For detailed specifications and application data send for Publication 6024.

Allen-Bradley Co., 140 W. Greenfield Ave., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

Actual Sizes

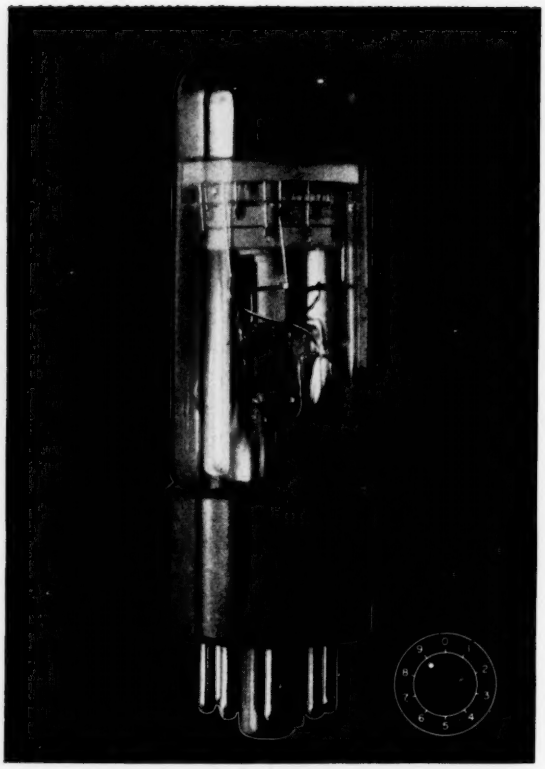


ALLEN-BRADLEY
QUALITY
ELECTRONIC COMPONENTS

A-B QUALITY

For more information circle **32** on inquiry card.

← Circle **31** on inquiry card.



Need a **PROVEN** tube that indicates and counts?

dekatron*

The only cold-cathode glow transfer counting tube **WITH OVER 10 YEARS OF SERVICE RELIABILITY AND PERFORMANCE.** Simple circuitry. Electronic speed and accuracy up to 20,000 counts/sec. For counting, sorting, programming, unit flow, packaging and many other applications. Continuous visual reference to total count. For detailed information, request Technical Data Sheet IC4001.

*Trademark

Baird Atomic

Baird-Atomic, Inc.

33 UNIVERSITY RD., CAMBRIDGE 38, MASS.

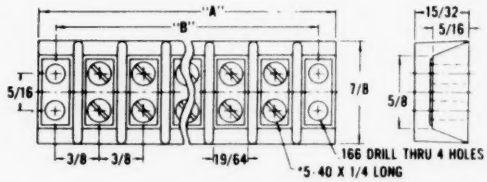
Instrumentation for Better Analysis

For more information circle **33** on inquiry card.

BRIEFS—CONTINUED

Solid-block Terminal Boards

(Features): Solid, insulated back, eliminates insulating strip; "molded-in" conductors; thicker, higher barriers; greater current carrying capacity; longer creepage path; boards can be marked on barriers,

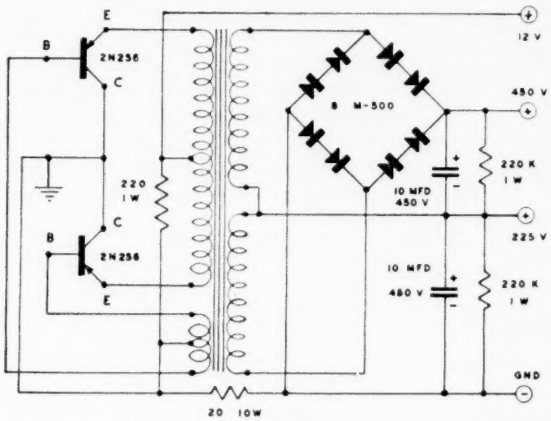


eliminating marker strips; molded-in insert reinforces mounting holes, eliminating saddle plates on mounting supports; electrical grade anti-corrosive molding compound; nickel plated connectors and screws throughout . . . (*From new 4-page bulletin, Gen-Pro, a div. of General Products Corp., Union Springs, N. Y.*)

For this literature circle **207** on inquiry card.

How to Build a Transistorized 40-watt Supply

The unit is built around one of the first commercial transformers available to the home constructor. It . . . permits the user the choice of two output voltages, 450 volts and 225 volts. Thus, both the receiver and transmitter can be operated from the same supply . . . Essentially, transistor power supplies are similar to blocking oscillators or multivibrators in vacuum



tube circuits. The two transistors operate as switches in the DC primary circuit and alternately allow current to flow through the transformer, first through one-half the primary and then through the other half of the primary. This sets up an AC square wave in the secondary which is then rectified by the silicon diodes in a bridge rectifier circuit. It is necessary to use two diodes in each leg of the bridge because the output voltage exceeds the ratings of a single diode . . . (*From new 5-page Bulletin E-279, CBS-Hytron, Danvers, Mass.*)

For this literature circle **208** on inquiry card.

Circle **34** on inquiry card. ⟶

Reliability

Yarn control of the Cobble Bros.' Tufting Machine is through electrical contact fingers which transmit impulses to 120 CLARE RELAYS each controlling two electro-magnetic clutches.

That's why

COBBLE BROS.' controls were designed around Clare Relays

"The most important reason Clare Mercury-Wetted-Contact Relays were chosen as the basic components for this control is their *reliability*."

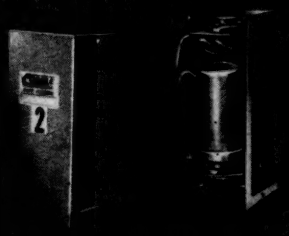
Assurance of billions of trouble-free operations caused engineers of Cobble Bros. Machinery Co. to design their electrical control system around Clare HG relays.

There are 120 Clare HG Relays in controls of the Cobble Yardage Tufting Machine shown. They receive impulses from 120 electrical contact fingers as they "read" the pattern. The relays operate electro-mechanical clutches to translate these impulses into intricate carpet designs.

Reliability means freedom from costly maintenance. If, like Cobble Bros.' engineers, you want only the best for your design, let us tell you ALL about Clare Mercury-Wetted-Contact Relays. Address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable address: CLARELAY.

CLARE RELAYS

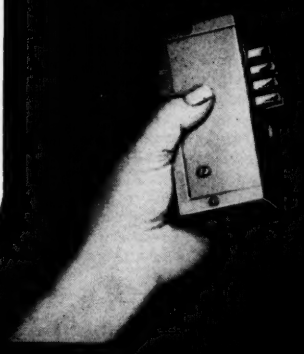
FIRST in the industrial field



Each relay is housed with a transistor in this modular type unit. The module is then plugged into the control system.

• • •

Send for Clare Bulletins 120 and 122



STOPPED!

LOST *10,000 man-hours*

and your high-paid help talks TV

Stopped . . . because automatic control circuits and operating elements were not designed on the modular basis, with Cannon quick-disconnect electrical connectors at vital points.

But it could have been rolling in seconds or minutes! If only the circuitry had been arranged on the modular basis so that essential elements of the automatic control and operating system could be disconnected quickly . . . and complete, operable spare components inserted at a moment's notice. The units in trouble could have been repaired properly, too, at leisure . . . by trained personnel, at the right place, with the right facilities. Production could have gone on . . . thousands of man-hours and thousands of dollars saved . . . merely by the use of quick-disconnect components.

Are the controls in your electrical or electronic product designed on the modular basis? How about your production line? Will minor failure cause breakdown? Or do you need Cannon Connectors? Cannon makes over 27,000 different electrical connectors. If one of these does not meet your requirements, we'll design and make the electrical connector you need. Write today! Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif. Please refer to Dept. 419.

Send for explanatory material on how modular designs can save dollars.

CANNON PLUGS

CANNON ELECTRIC

Where Reliability for Your Product is Our Constant Goal

COPYRIGHT 1958, CANNON ELECTRIC CO.

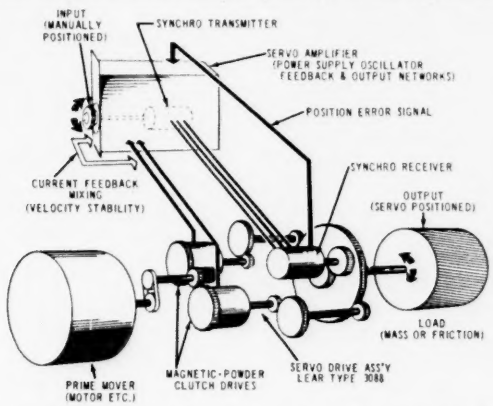
Binary Resistance Set

The (BMR-105) unit consists of 17 ultra-precision resistors having values in a binary sequence . . . Applications as a resistance standard: 127,000 resistance values more accurate than 0.01%. By series combination have 131,071 resistance values in 1-ohm steps. All values above 3350 ohms are 0.1% of value or better. Maximum Resistance—R_{max} = 131,071 ohms; Accuracy—R_{max} within 0.0015% of resistance standard; Stability—0.0015%; Resolution—1 ohm; Temperature Coefficient—within 5 ppm/°C.; All thermally induced transient effects are less than 0.0005% of full scale at rated current . . . (*From new 8-page "Summary Data Sheet," which also describes voltage standards, voltage dividers, synchro and resolver bridges, etc. Resistor Networks, Inc., a Div. of Julie Research Labs., Inc., 556 W. 168th St., New York 32, N. Y.*)

For this literature circle **209** on inquiry card.

Positioner Servomechanism

The Electrolink "60" consists of a combined controller-amplifier and a servo drive. The controller converts movement of a manual control (dial, lever, or pre-set push button) into an electrical error signal. The amplifier discriminates polarity of the signal and


INPUT (MANUALLY POSITIONED)
SYNCHRO TRANSMITTER
SERVO AMPLIFIER (POWER SUPPLY OSCILLATOR FEEDBACK & OUTPUT NETWORKS)
POSITION ERROR SIGNAL
SYNCHRO RECEIVER
CURRENT FEEDBACK MIXING (VELOCITY STABILITY)
OUTPUT (SERVO POSITIONED)
LOAD (MASS OR FRICTION)
PRIME MOVER (MOTOR ETC.)
MAGNETIC-POWDER CLUTCH DRIVES
SERVO DRIVE ASS'Y LEAR TYPE 3088

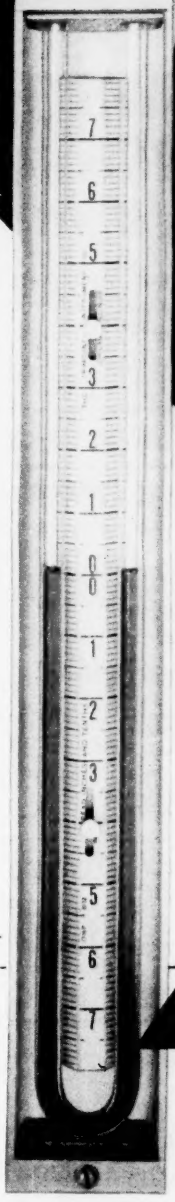
transmits a current (proportional to the error signal) to one of the two magnetic-powder clutches in the servo drive, which rotates the output shaft in the commanded direction. Exceptional loop stability, which all but eliminates overshoot, is achieved by a unique time-delay clutch current feedback network and a balanced gear train which eliminates backlash . . . The patented clutches contain a metallic powder in the air gap between the continuously rotating clutch bodies and their respective low-inertia output shafts. When energized, the magnetic particles span the gap and couple the body and the shaft. The shear strength of this magnetized mass of particles is proportional to the excitation current, and torque output is essentially linear with excitation current . . . (*From new 2-page Product Data Sheet* 112-8, *Lear, Inc., Grand Rapids Div.*, 110 *Ionia Ave., N.W., Grand Rapids* 2, *Mich.*)

For this literature circle **210** on inquiry card.

NEW!

from TRIMOUNT

MODEL F-30 U-TUBE MANOMETER



THE ULTIMATE IN ACCURACY AND CRAFTSMANSHIP!

The most demanding requirements of engineers and technicians have been fulfilled with the Trimount Model F-30 U-Tube Manometer! New and compact in design, the Model F-30 incorporates every known advance relative to U-Tube Manometer construction. The body is of extruded aluminum and the head is easily removed for cleaning. Overall design is clean and modern, contributing outstanding readability ease and accuracy. Other features of the Trimount Model F-30 U-Tube Manometer emphasize the inherent accuracy, dependability and versatility of this precision instrument.

ONLY FROM TRIMOUNT . . . A LOW COST MANOMETER WITH THESE QUALITY FEATURES:

RANGE: 6" to 60".
SCALE: English or Metric Units.
CONSTRUCTION: Open, or fully enclosed with glass cover.
FINISH: Gold anodized aluminum.
CONNECTIONS: ¼" NPT for Top, Side, or Back Connecting.
MOUNTING STYLES: Bench, Wall, Front of Panel, or Flush Panel.

FLUID CONTACTED PARTS

Model F-30 . . . Steel and Pyrex.
Model F-31 . . . Brass and Pyrex.
Model F-32 . . . 18-8 Stainless Steel and Pyrex.

Above specs regarding range, scale, etc. apply to all three models.

WRITE FOR CATALOG AND FULL INFORMATION.

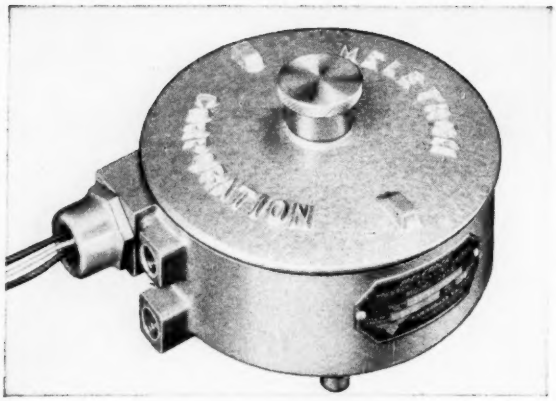
TRIMOUNT INSTRUMENT COMPANY
Dept. 1A-78,
3119 West Lake Street, Chicago 12, Ill.

Gentlemen: Please send me full information regarding the Trimount line of Manometers, including the Model F-30.

Name .....
Title .....
Company .....
Address .....
City ..... Zone ..... State .....

For more information circle **36** on inquiry card.

← Circle **35** on inquiry card.



MELETRON

DIFFERENTIAL SWITCH

senses pressure differences from .45 to 45 inches of water

Used in hopper level indicating, on oil burner blower safety control, in instrumentation or similar applications where it is necessary to sense a pressure difference of .45 to 45 inches of water between a variable and a reference pressure. The reference pressure may be as high as 30 P.S.I.

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	**LINKAGES & BEARINGS** which as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements.	**LIQUID SWITCHING ELEMENTS** which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	**ACCORDION DIAPHRAGMS** which make the pressure switch sensitive to vibration.

To get complete specifications and operating data ask for bulletin 227 and 2273.

PRESSURE SWITCH DIVISION

Barksdale valves

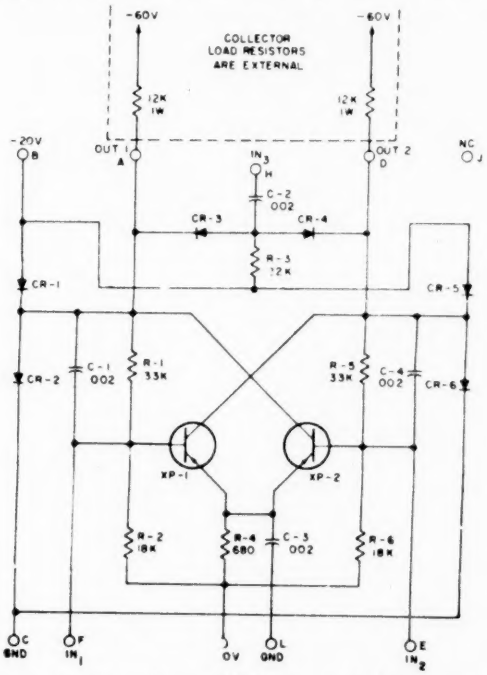
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

For more information circle **37** on inquiry card.

BRIEFS—CONTINUED

Transistorized Circuit Modules

The "Flip-Flop," or Eccles-Jordan type circuit, is a two-stage amplifier in which the output of the second stage is coupled back into the output of the first. The

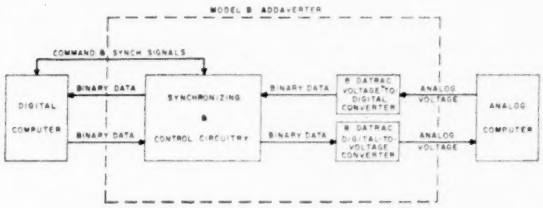


circuit is a bi-stable multivibrator with clamped output levels, and three inputs. Operating frequency is 0-40 kc . . . *(From new 2-page Rixon Engineering Bulletin, Rixon Electronics, Inc., 2414 Reedie Dr., Silver Spring, Md.)*

For this literature circle **211** on inquiry card.

Model B Addaverter

The Model B Addaverter consists of two Epsco model B Datrac A-D and D-A converters, as well as control and synchronizing circuitry. The linkage equipment is commanded either by the digital computer or an external clock . . .



Voltage to digital conversion: Resolution—10 binary digits plus sign bit; 3 decades plus sign, binary coded decimal. Accuracy—$\pm 0.05\%$ or $\pm \frac{1}{2}$ of least significant bit. Conversion time—less than 30 usec. Conversion rep. rate—33 Kc max.

Digital to voltage conversion: Conversion time—2 usec max. Output voltage—± 100 v.—*(From new 2-page engineering data sheet, Epsco Incorporated, 588 Commonwealth Ave., Boston 15, Mass.)*

For this literature circle **212** on inquiry card.

New program timer features complete adjustability

In many applications, a timer has a "standard" job to do throughout its expected life, never requiring a change of timing sequence. But in many others, it's desirable to be able to change the timing sequence and the intervals making up the sequence in a complete cycle.

The new Cramer Type 511 and Type 521 Cycling Timers fill the bill for a unit combining high accuracy with complete field adjustability of as many as eight individual timed intervals. Although these timers can be supplied with preset cams to fit the needs of a present application, the added feature of adjustability makes them the ideal choice where the timing sequence may later be changed.

Operation

Applying power through an external sustained contact starts the timer, which continues to cycle until the control contact is broken. Full cycle time is the total time range of the timer specified, and may be selected from a large number of available ranges. If desired, the timer can be wired to perform one cycle and stop.

At the start of each cycle, the snap-acting SPDT load switches are in the initial positions specified (or established through adjustment) by the user. As the cycle progresses, each load switch is transferred by its operating cam to open or close its connected circuit at the required time and for the required duration.

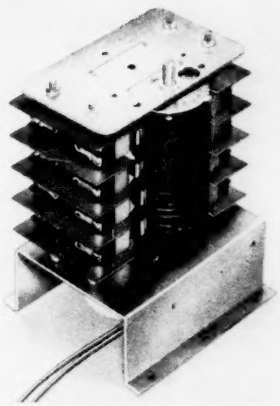
Timing Cam Adjustment

Each SPDT switch is operated by a double cam, one section to close the switch to one contact, the other to close it to the opposite contact. Depending on circuit wiring, either of these actions can "make" or "break" the load circuit. Each section of each cam is independently adjustable through a full 180°, without disturbing any other cam setting, by means of a small spanner wrench furnished with the unit. Adjustment is indicated on a dial which is marked in percent of total cycle time, permitting accurate selection of the desired "make" and "break" points for each load switch.

Features

TIME RANGES — From 1 cycle in 6 seconds to 1 cycle in 48 hours.

LOAD CIRCUITS — From 1 to 3 (Type 511) or from 4 to 8 (Type 521), each controlled by a totally-enclosed quick-make quick-break SPDT switch rated for 20 amperes at 125 or 250 volts AC (non-inductive).



Field-Adjustable Program Timer Type 521

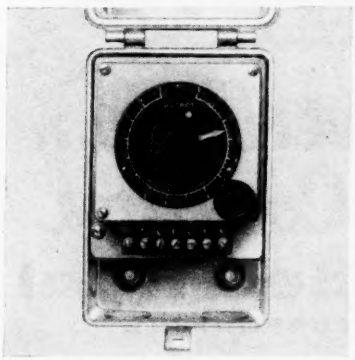
OPERATING TIME — Minimum operating time for each circuit is approximately 1/30 of total cycle time.

ACCURACY — At operating point of any one circuit, 1½°; between any two circuits, 3°.

MOTOR — Cramer high-torque synchronous, for 115 and 230 volts, 25, 50 and 60 cycles. Motors for operation on DC or at other frequencies are available in limited time ranges.

For detailed information and complete specifications, write Cramer Controls Corporation, Box 5, Centerbrook, Conn.

THREE MORE WAYS TO SOLVE YOUR TIMING PROBLEMS

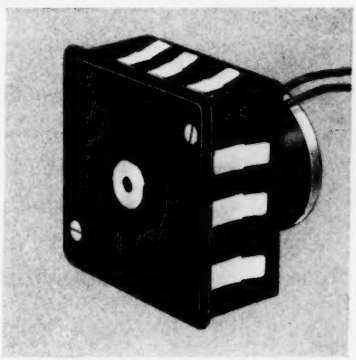


VARIABLE-CYCLE PULSE TIMER TYPE 650

Makes or breaks an electrical circuit for a fixed period or "pulse" of ½ second to 12½ hours, at continuously repeated intervals that are adjustable from ¾ second to 24 hours. By choice of load connection, control can be based either on the fixed pulse time or on the adjustable interval between pulses. Cycling period can easily be changed during operation.

ADJUSTABLE PERCENTAGE TIMER TYPE 610

Makes or breaks an electrical circuit for a variable percentage of a basic fixed cycle time. Desired percentage of total cycle time, for ON or OFF control of the timed device, is adjustable from 4% to 96% in steps of 1%. Total cycle-time ranges from 15 seconds to 24 hours. Internal connections can easily be arranged so that the load circuit is either closed or open for the indicated percentage of the full cycle.



CYCLING TIMER TYPE 571

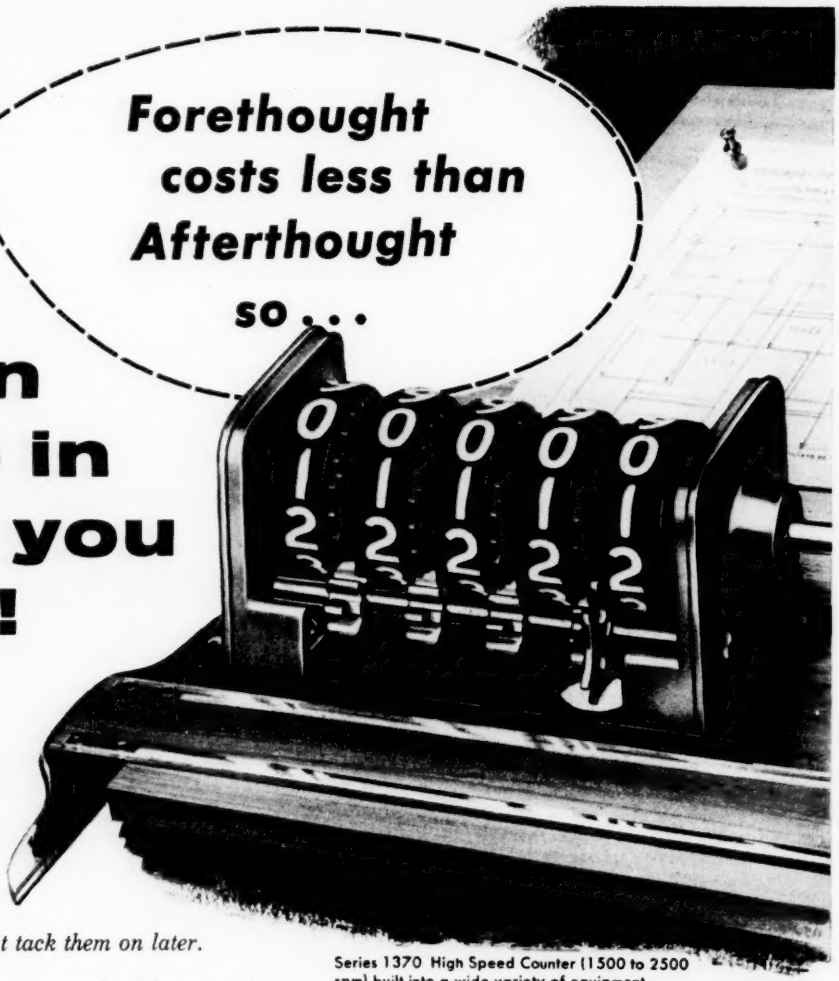
Provides reliable and inexpensive control of repetitive switching for built-in applications. One through four poles, SPST or SPDT open-blade switches with contacts rated at 30 amperes, each controlled by a timing cam specially cut to user's requirements. 18 standard speeds from 1 rpm to ⅛ rpd, plus many special time ranges.

CRAMER CONTROLS
CORPORATION
Box 5, Centerbrook, Connecticut

For more information circle **56** on inquiry card.

Forethought costs less than Afterthought so . . .

Design These in When you Begin!



If you need mechanical or electrical counters in any of your new products, here's a word to the cost-wise designer: *Design them in, when you begin . . . don't tack them on later.*

Series 1370 High Speed Counter (1500 to 2500 rpm) built into a wide variety of equipment.

For if you'll give us a chance to work with you, right from the beginning, chances are we can save you time and money by adapting or modifying a *standard* Veeder-Root Counter to your needs . . where you might get into a costly special job if you went about it alone. What's more, you save time in your engineering, purchasing and assembly departments.

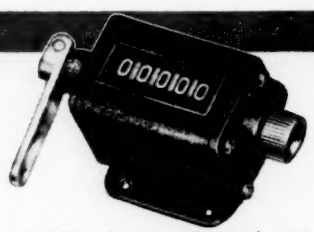
Count on Veeder-Root to help you in every way . . . from design to delivery. Write:

Everyone... Can Count on Veeder-Root

INCORPORATED

Hartford, Conn. • Greenville, S. C. • Chicago
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

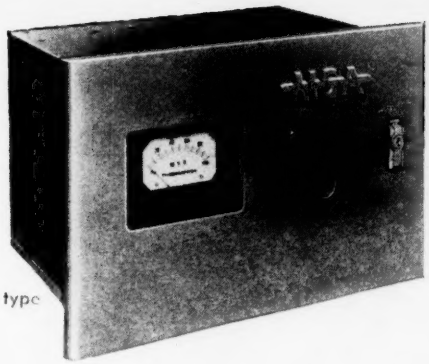
Series 1205 Reset Magnetic Counter with panel mount and lock and key.



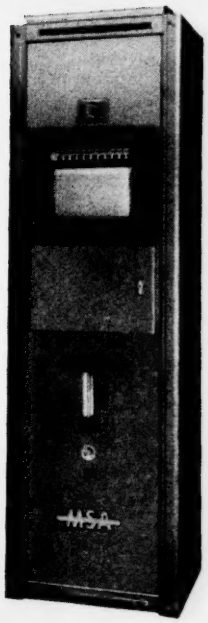
Series 1122 Small Reset Ratchet Counter.

Special Longitude Counter, one of many made for aircraft navigational equipment.

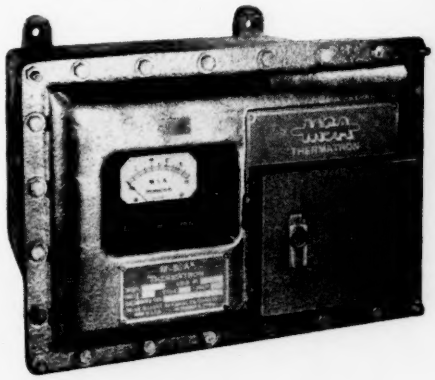
For more information circle **39** on inquiry card.



Non-explosion-proof type

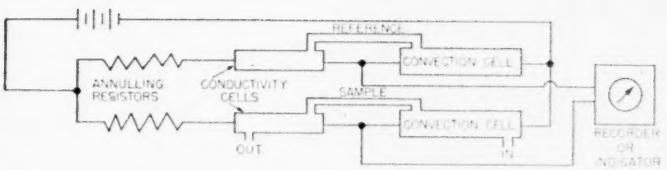


A non-explosion-proof type of M-S-A Gas Thermatron with recorder mounted in cubicle



Explosion-proof type

M-S-A® Gas Thermatron continuously analyzes for one component in multi-component gas mixtures



Schematic Flow and Wiring Diagram

This unique development in gas analysis instrumentation combines thermal convection and thermal conductivity effects to provide selective measurement of a single component of a mixture without "scrubbing out" interfering components.

MSA has been applying its knowledge of gas analysis to specific customer problems for over 30 years. Latest and most unique solution to some of these problems is the M-S-A Gas Thermatron.

This unit selectively analyzes for one component of at least a ternary mixture of gases (without removal of any component) by employing both thermal conductivity and thermal convection properties of the gas.

Other standout features: Calibration is possible over very narrow or very wide ranges (0-100% Gas). Construction is rugged. Operation is stable. Maintenance is simple, infrequent. High accuracy and speed of response are inherent characteristics.

In process control, you can use the selective M-S-A Thermatron for analysis of components in hydrogenation, ammonia synthesis, hydrocarbon synthesis and other processes.

In the area of atmosphere/combustion control, you can analyze for CO_2 or H_2 in atmospheres containing H_2, CO_2, N_2, CO and water vapor. Or, for CO_2 in flue gases.

And where gas purity is a factor, the M-S-A Thermatron is helpful in the analysis of argon, hydrogen, helium or water vapor in oxygen, air or nitrogen.

The MSA Instrument Specialist will welcome an opportunity to relate these advantages to your specific operation. Contact him soon. And write us for informative new bulletin on this inexpensive thermal conductivity analyzer.

INSTRUMENT DIVISION

Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

For more information circle **40** on inquiry card.

MSA

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters

Here is Why!

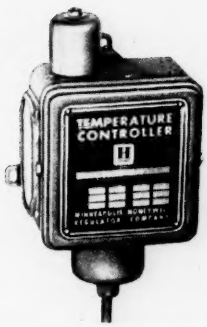
You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

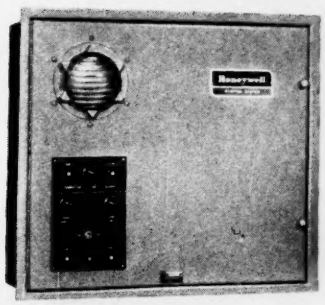
No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

PRESSURE CONTROLLERS for high or low-limit cutoff or signalling, or for control of pressure and vacuum in many ranges from 0 to 1000 psi.

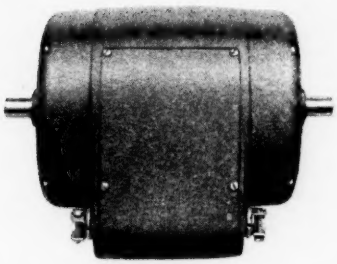


REMOTE BULB TEMPERATURE CONTROLLERS for high or low-limit cutoff . . . signalling . . . and automatic on-off, two-position, floating or proportional control with electrically or pneumatically operated valves, dampers, refrigeration units and similar equipment.



***PROTECTOGLO* FLAME SAFEGUARDS** instantly detect flame failure in gas or oil fired burners, and immediately shut off fuel supply, sound an alarm, and perform other functions to guard against explosion hazards.

Add low-cost automation ...with Honeywell industrial controls



INDUSTRIAL MOTORS for electrical operation of valves, dampers and auxiliary switches.

ALARM SILENCING RELAYS permit an alarm to be silenced, and light an integral red light until an unsafe condition has been corrected. Relay automatically resets the alarm when safe conditions are restored.

You don't have to spend a lot of money for dependable automatic controls. Like many manufacturers, you can use various Honeywell industrial controls as the efficient, low-cost means of automating your equipment . . . improving performance . . . increasing safety. And, you can use these inexpensive controls to save time, money and space by extending automation in your plant or process.

There are more than 9000 standard types of Honeywell controls to handle temperature, pressure, liquid level and humidity—for control, switching or safety functions. There are electric, electronic and pneumatic types.

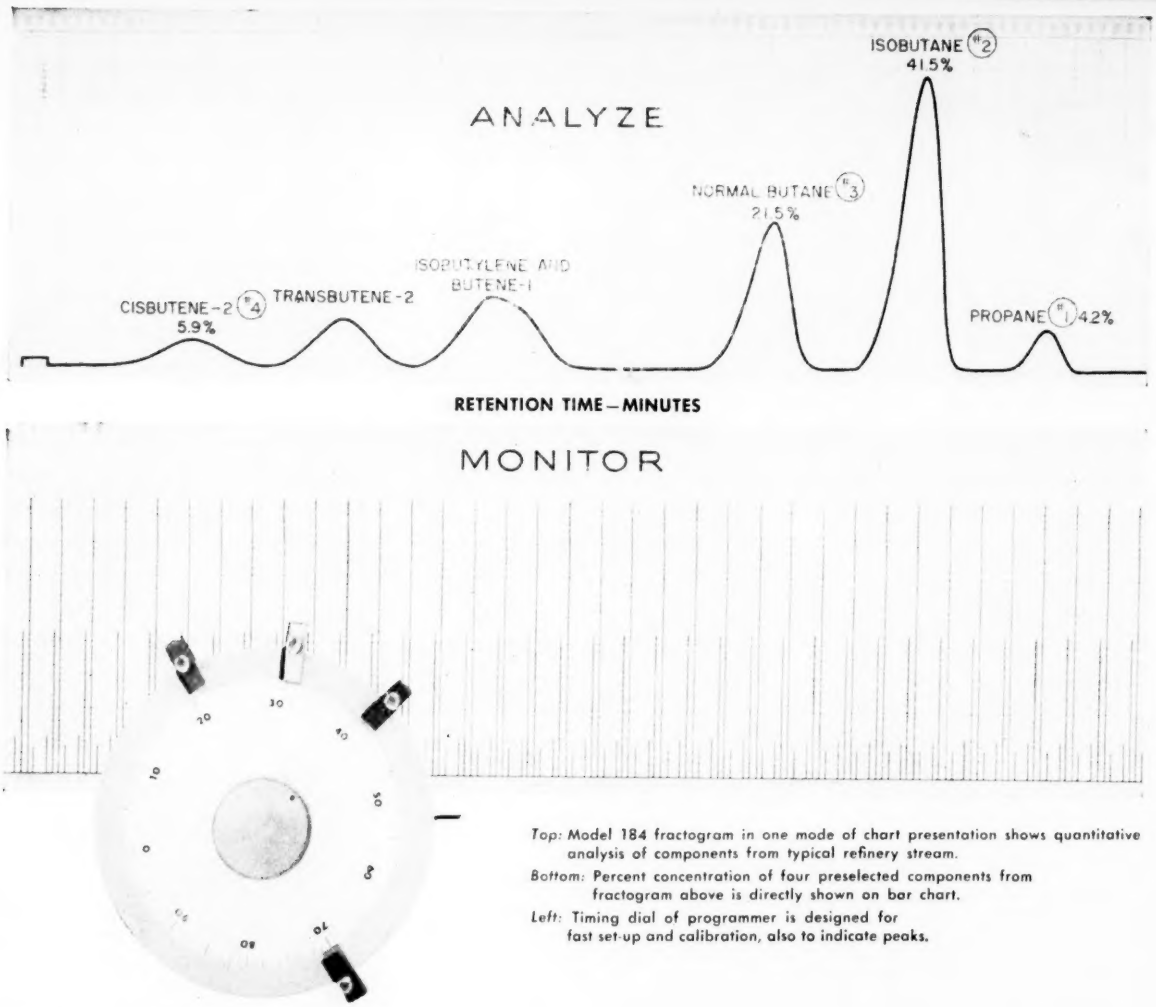
Though they're low in cost, these controls are top-quality, reliable devices. If there's not already a standard control for your particular application, Honeywell can design and build one for you.

Your nearby Honeywell field engineer will be glad to discuss your control requirements. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

H HONEYWELL *First in Controls*



Top: Model 184 fractogram in one mode of chart presentation shows quantitative analysis of components from typical refinery stream.

Bottom: Percent concentration of four preselected components from fractogram above is directly shown on bar chart.

Left: Timing dial of programmer is designed for fast set-up and calibration, also to indicate peaks.

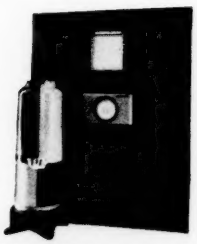
A New Instrument for

AUTOMATIC PLANT STREAM ANALYSIS BY GAS CHROMATOGRAPHY

After more than a year of field tests with ten leading oil and chemical companies, a new process vapor fractometer is now commercially available for multi-component analysis and monitoring of process streams.

The Model 184 is simple, versatile and reliable. Long term accuracy under plant conditions was a prime design consideration. Reproducibility is unequaled. Every safety feature has been incorporated.

Thanks to its in-plant evaluation by top instrumentation and process control engineers, the new P-E Model 184 can be put on stream with confidence—next year's afterthoughts are already built in.



Model 184 consists of analyzer unit in explosion-proof housing, panel mounted programming and recording units. Instrument monitors up to four components directly on bar chart.

INSTRUMENT DIVISION

Perkin-Elmer *Corporation*

NORWALK, CONNECTICUT

For more information circle **41** on inquiry card.

Panhandle Pete

The 4-C Problem

ONLY four things keep this instrument business from being real enjoyable," says Bus, 4-card Wallace, our genial sales manager, as the executive staff of WESCO! was gathered for our daily KS session. (Editor's note—I think that means Kreigspeil—but it could just be a typo, in which case you know what it means.)

"Just four?" asks Waldo.

"Yep, just four," replies Bus—"Cash, costs, customers and competition."

"If these are the only four aggravations you get, how would you like to eliminate all four at one swell foop—er, one fell swoop," says I, trying hard to justify my executive position in the company.

"Pete, just get rid of one of these problems and we will give you a bonus," says Bus.

"Well, get four bonuses ready," says I. "Because this idea got no cash, cost, customer or competition trouble."

"It is really very simple. The guvermint is spending $40 billion on missiles, rockets, satellites, atom bombs, and other anti-recession weapons. One of their main problems is gas analysis near atom bombs and in the upper atmosphere. In fact, they will pay millions for a solution to this problem—and we have the cheapest gas analyzer on the market, our Kanarienvogle."

"Now wait a minute," says Bus," Are you suggesting that we put our Kanarienvogle near atom bombs and in outer space?" They haven't been designed to . . . and the SPCA might . . ."

"Please do not interrupt until I am through" says I. "After all, this is a million dollar idea. Give me at least ten cents worth of time. Of course there will be problems to solve—that is why the guvermint is ready to spend millions to solve them. What we do is simple—we bid only $1 million for the gas analysis problem on the ARCD-JPD-4XU-JAN-UPRAIR-WHEE project."

"But that project will require at least $2 million to solve some of the technical problems involved at upper atmosphere temperatures and pressures," counters Bus, who is indeed a skeptic.

"Please hear me out, Bus," says I. "As soon as we get the contract, we deliver two Kanarienvogles, which solve the problems at altitudes from 0 to 20,000 ft altitude, leaving only the problem from 20,000 to 400,000 ft to solve."

"Having solved part of the problem, we take our $1 million contract to the bank and borrow $200,000. That solves our cash problem. The $1 million bid on the $2 million project solves the competition problem. The guvermint solves the customer problem. And the Kanarienvogle solves the cost problem. Voila—all your problems are solved. Where's my bonus?"

"But what happens at altitudes above 20,000 ft," injects one-thought Waldo. "Our Kanarienvogle needs air and the SPCA might . . ."

"The SPCA won't dare interfere with a defense project, I replies. "And did you ever see a project as big as the ARCD-JPD-4XU-UPRAIR-WHEE project that solved all its problems in advance? With $200,000 we'll hire us a stratosphere expert. Let him solve the problem. Besides, the guvermint is reasonable. When they hear we are in trouble, they'll readjust the contract."

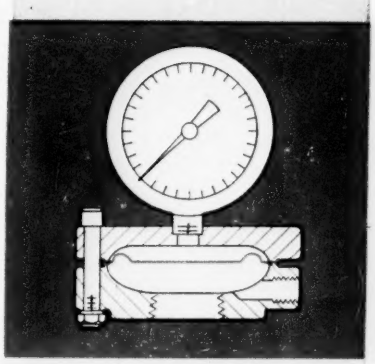
"But isn't there a matter of ethics involved in bidding $1 million on a project that you know is going to cost $2 million?" says Bus.

"Of course," I replies, "But I didn't say my solution was ethical—all I said was that it solved your cost, cash, customer and competition problems. If you would rather have ethics than contracts, that's up to you—I'm only a salesman. Now where's my bonus?"

"You might deserve the bonus," says Bus, "Even if WESCO! wouldn't think of compromising its principles. Except for one thing—the idea isn't new. So many companies are bidding like that that we probably wouldn't get the contract even at a $1 million bid."

Panhandle Pete

WHAT'S INSIDE MAKES A BIG DIFFERENCE



Vulcan diaphragms have been accepted and depended on for almost 25 years.

Low gauges are available with excellent flexibility for delicate applications. Heavy gauges with high strength for rugged service are available in many coating compound types.

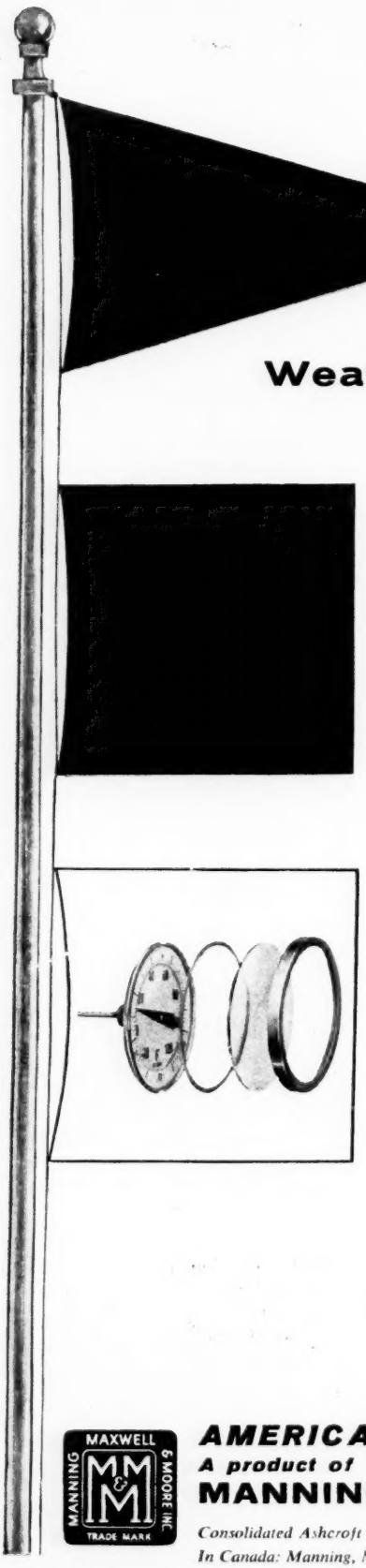
Vulcan provides integrated research, development and manufacturing facilities. This means complete quality control from raw material to finished product; assuring you that every diaphragm is made to strict specifications.

A vital part of this Vulcan integration is our research and development laboratory. If you have a diaphragm problem, we shall be happy to consult with you.

Another

REEVES VULCAN RUBBER PRODUCT

Write to: Dept. 1-87
REEVES BROTHERS INC.
Vulcan Rubber Products Division
54 Worth Street • New York 13, N.Y.



Weather-proof construction stymies erosion and corrosion

Complete protection against erosion and corrosion is built into American Bi-Metal Thermometers, so you can always be sure of accurate temperature measurement. Both case and bezel are stainless steel, precisely fitted and gasketed to insure snug mating. Whatever the weather, rain, sand, dust, dirt, fumes and frost are sealed out by a heat-resistant gasket between case and thick cover glass.

The stem of the American Bi-Metal Thermometer is mirror-smooth stainless steel. All joints are solidly welded. Top resistance to corrosion is teamed with strength, rigidity and tight closure against process pressures.

Weather-proof American Bi-Metal Thermometers are noted for high sustained accuracy and long service life. There are mounting styles, dial sizes, temperature ranges and stem lengths to meet your needs exactly. Ask your industrial supply distributor for help in proper selection.

American Bi-Metal Thermometer with weather-proof stainless steel construction.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

AMERICAN INDUSTRIAL THERMOMETERS

A product of

MANNING, MAXWELL & MOORE, INC.

Consolidated Ashcroft Hancock Division • Stratford, Connecticut

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more information circle **43** on inquiry card.

events

August 6-8

Special Technical Conference on Non-Linear Magnetics sponsored by the AIEE, Hotel Statler, Los Angeles, Calif. For information write to Special Technical Conference, Box 2025, Downey, Calif.

August 10-16

First International Congress of Radiation Research, University of Vermont, Burlington, Vermont. For information write Howard J. Lewis, National Academy of Sciences, National Research Council, 2101 Constitution Ave., Washington 25, D. C.

August 13-15

7th Annual Conference on Industrial Applications of X-ray Analysis at Albany Hotel, Denver, Colo. For further information contact William M. Mueller, Metallurgy Div. Denver Research Institute, University of Denver, Denver 10, Colo.

August 13-15

AIEE, IRE and NBS Conference on Electronic Standards & Measurements, NBS Boulder Laboratories, Boulder, Colorado. For information write James F. Brockman, Boulder Laboratories, National Bureau of Standards, Boulder, Colorado.

August 19-22

WESCON (Western Electronics Show and Convention) co-sponsored by the San Francisco and Los Angeles sections of IRE and the West Coast Electronic Mfg. Assn., Pan Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif. Write Ted Shields, General Public Relations, Inc., 607 S. Hobart Blvd., Los Angeles 5, Calif.

August 25-27

Appalachian Gas Measurement Short Course, University of West Virginia, Morgantown, W. Va. For information write Earl A. Mowrey, 400 N. Lexington Ave., Pittsburgh 8, Pa.

August 25-29

Infrared Spectroscopy Institute, Fisk University, Nashville, Tenn. For information write James R. Lawson, Associate Director of Fisk Infrared Spectroscopy Institute, Nashville, Tenn.

Sept. 1-5

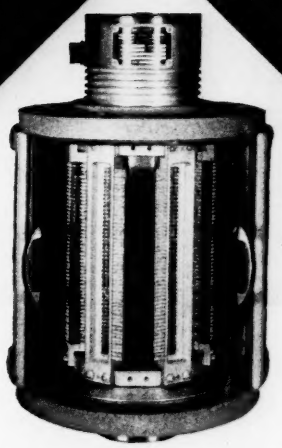
Second International Conference for Analog Computations of the International Association for Analog Computations, Strasburg, France. For further information contact F. H. Raymond c/o S.E.A., 138 Blvd de Verdun, Courbevoie (Seine) France.

Now you can order from stock...

the new

BRYANT MAGNETIC STORAGE DRUM

Unequalled for precision, versatility, and low cost



The new 512A Bryant general purpose magnetic storage drum meets the exacting demands of all permanent storage problems, yet is versatile enough to be used as a laboratory instrument. These 5" dia. x 12" long drums are stocked for immediate shipment at a price that is far below the cost of customer-designed drums.

Features: Guaranteed accuracy of drum run-out, .00010" T.I.R. or less; Integral motor drive; Capacities to 625,000 bits; Speeds up to 12,000 R.P.M.; 500 kilocycle drum operation possible; Accommodates up to 240 magnetic read/record heads; For re-circulating registers as well as general storage.

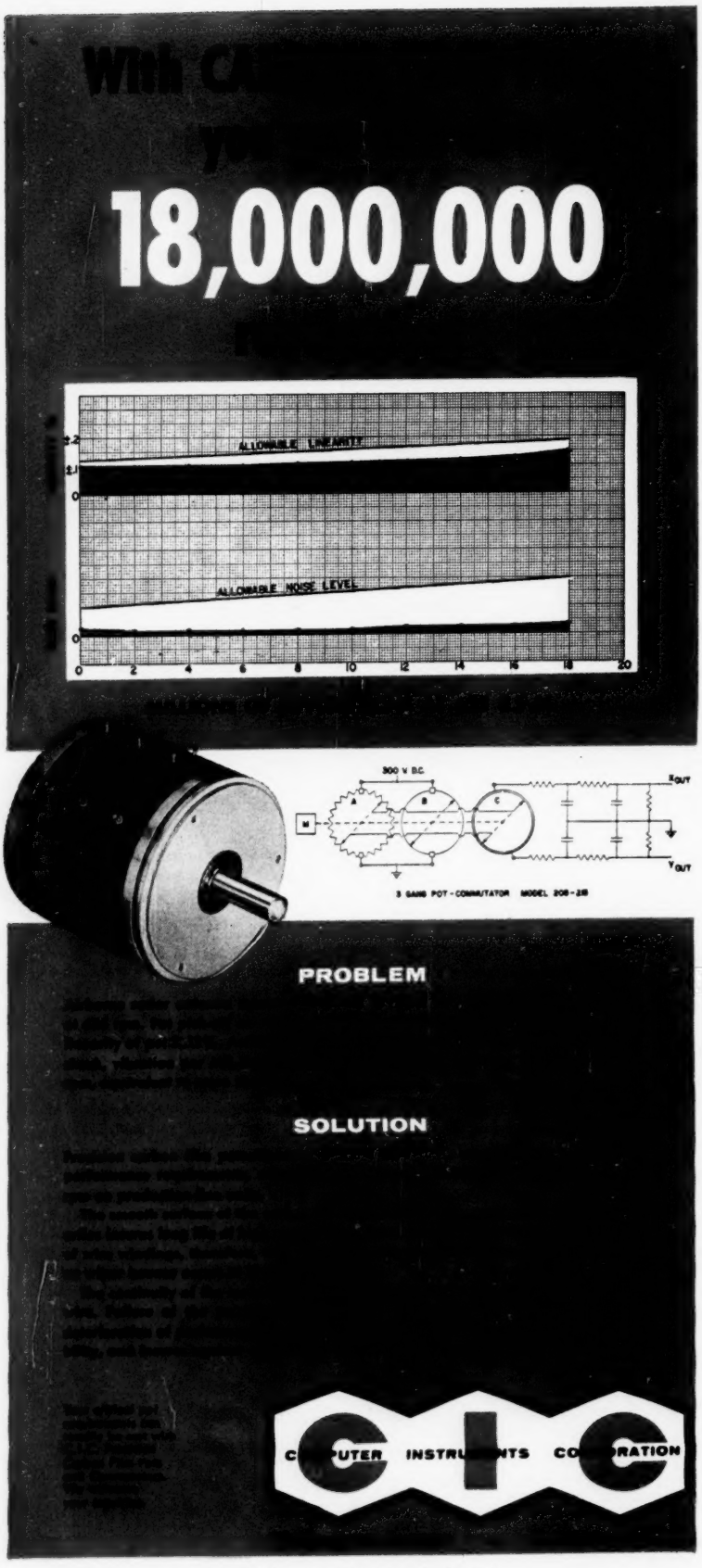
Special Models: If your storage requirements cannot be handled by standard units, Bryant will assist you in the design and manufacture of custom-made drums. Speeds from 60 to 120,000 R.P.M. can be attained, with frequencies from 20 C.P.S. to 5 M.C. Sizes can range from 2" to 20" diameter, with storage up to 6,000,000 bits. Units include Bryant-built integral motors with ball or air bearings. Write for Model 512A booklet, or for special information.

BRYANT GAGE and SPINDLE DIVISION

P. O. Box 620-I, Springfield, Vermont, U. S. A.

DIVISION OF BRYANT CHUCKING GRINDER CO.

For more information circle **44** on inquiry card.



For more information circle **45** on inquiry card.

EVENTS—CONTINUED

Sept. 3-5

Cryogenic Engineering Conference, Massachusetts Institute of Technology. For more information write K. D. Timmerhaus, Dept. Chemical Engineering, University of Colorado, Boulder, Colorado.

Sept. 3-5

NEMA and AIEE First National Conference on Application of Electrical Insulation, Cleveland, Ohio. For information write George Bamberg, The Glastic Corp., 4321 Glenridge Rd., Cleveland 21, Ohio.

Sept. 3-10

International Association for Cybernetics Second International Congress Namur, Belgium. For information write Secretariat, 13, rue Basse-Marcelle, Namur, Belgium.

Sept. 8-13

First International Congress of the Aeronautical Sciences planned by the International Council of the Aeronautical Sciences, Madrid, Spain. For information write Institute of Aeronautical Sciences, 2 East 64th Street, New York 21, N. Y.

Sept. 15-19

13th Annual Instrument Society of America Conference and exhibit will be held in Philadelphia. For further information contact H. S. Kindler, Dir. of Technical Programs, Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pa.

Sept. 15-17

AIEE Power Industry Computer Application Conference, King Edward Hotel, Toronto, Canada. For information write J. R. Leslie, Ontario Hydro, 620 University Ave., Toronto 2, Ontario, Canada.

Sept. 22-24

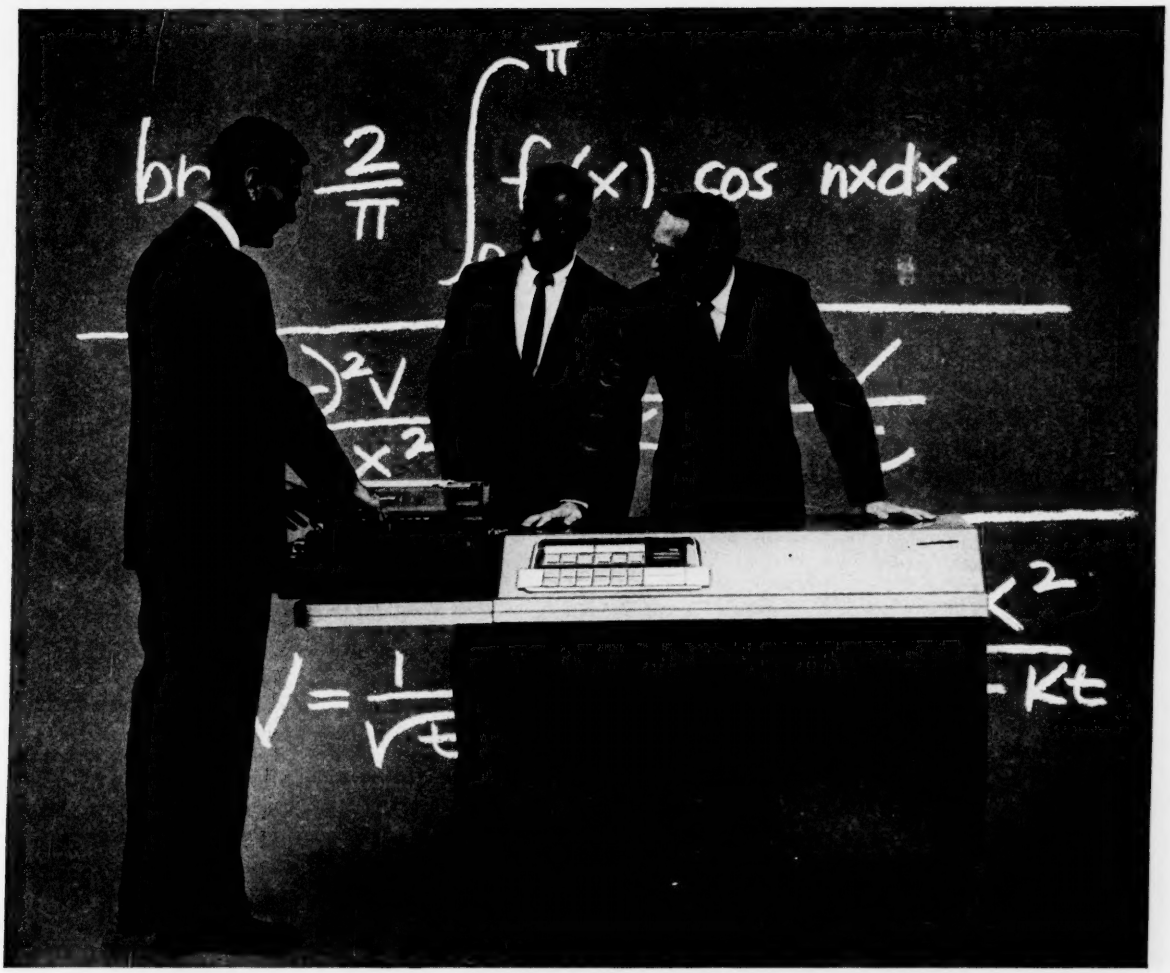
Symposia and exhibits of The Professional Group on Telemetry and Remote Control of the IRE, Americana Hotel, Bal Harbour, Miami Beach, Fla. For information write Conrad H. Hoeppner, Radiation Inc., Melbourne, Florida.

Sept. 24-25

Seventh Annual Symposium on Industrial Electronics, of the IRE Rackham Memorial Auditorium, Detroit, Michigan. For information write William R. Thurston, IRE Professional Group on Industrial Electronics, General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Oct. 13-15

1958 National Electronics Conference—the 14th Annual Forum on Electronic Research, Development and Application sponsored by the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, and Northwestern and Illinois Universities, Hotel Sherman, Chicago. For information write National Electronics Conference publicity chairman, c/o Illinois Bell Telephone Co., 208 W. Washington St., Chicago 6, Ill.



Speed routine calculations—increase creative time with this powerful electronic computer ROYAL PRECISION LGP-30

Large capacity... easily programmed and operated... mobile... low in cost

Compact, simple to use, Royal Precision LGP-30 will today bring high-speed computation *right to your desk* ... thus relieve you of the tedium of standard hand calculations... increase available time for truly creative work... help you simulate optimum designs in a matter of minutes. And at the lowest cost ever for a complete computer system!

Unusual capacity. Operating from a standard wall outlet, performing an almost unlimited range of calculations, LGP-30 gives you the flexibility of stored-program operation combined with speed, memory (4096 words) and capacity equal to computers many times its size and cost. Completely mobile, LGP-30 is easily wheeled from room to room, building to building.

Simple to operate and program. LGP-30 controls have been so thoroughly simplified that it may be operated with only minimum computer experience. Direct print-out of answers – no deciphering required. Programming is easily learned–even by non-technical personnel. Library of sub-routines, plus programs for a wide variety of applications, is available.

Wide range of applications. In addition to general design and system optimization, LGP-30 is currently being used for the refinement of estimates; computation of design parameters; specification of new product properties and capabilities; calculation of such data as reactance, load saturation curves, time constants, harmonics, torque-speed and vee curves.

Exceptional value; complete service. Smallest initial investment ever for a complete computer system is combined with low operating and maintenance costs. Service facilities coast-to-coast.

For further information and specifications, write Royal McBee Corporation, Data Processing Division, Port Chester, N. Y.

ROYAL McBEE

WORLD'S LARGEST MANUFACTURER OF TYPEWRITERS
AND MAKERS OF DATA PROCESSING EQUIPMENT

For more information circle **46** on inquiry card.

How to get maximum combustion efficiency . . . measure both combustibles and oxygen

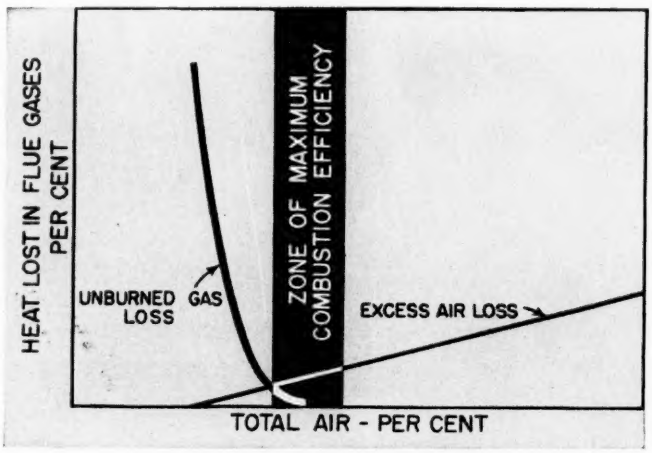
Simultaneous measurement of both oxygen and combustibles is needed to obtain optimum combustion. No instrument that measures only one of these two interdependable factors can give you the full information necessary.

Now, Bailey offers two units, each giving a continuous and simultaneous double check on combustion efficiency: a permanent analyzer-recorder which records both factors on a single chart; and a new light weight, portable unit which indicates both factors.

Both instruments measure: (1) excess air—regardless of the fuel or combinations of fuel being burned. (2) mixing efficiency of your fuel burning equipment by showing per cent combustibles in the flue gas.

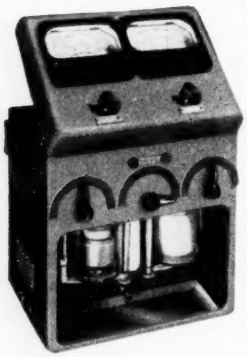
Both units are designed to increase efficiency in the furnace operations of the steel industry, on glass tanks, cement and lime kilns, ceramic and refractory kilns, steam boilers and also on direct and indirect-fired furnaces in the metal processing industries.

To prevent your money from becoming waste gas, look into these two efficiency provers. A Bailey engineer will be glad to give you details or write us for product specifications.


HEAT LOST IN FLUE GASES PER CENT
UNBURNED GAS LOSS
ZONE OF MAXIMUM COMBUSTION EFFICIENCY
EXCESS AIR LOSS
TOTAL AIR - PER CENT

Maximum Combustion Efficiency is secured by keeping the sum of Excess Air Loss and Unburned Gas Loss to a minimum. To do so by the direct method simply measure both oxygen and combustibles in flue gas.

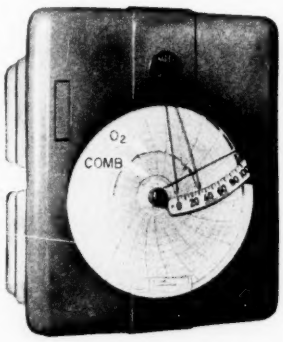
For portable use—
HEAT PROVER Analyzer



The famous Cities Service HEAT PROVER analyzer is now Bailey built and sold. Weighing only 25 pounds, it is a self-contained automatic analyzer including a sampling tip and hose plus a thermocouple for temperature measurement.

Instrument dials are dual range for greater accuracy and sensitivity.

For permanent installation
Oxygen-Combustibles Recorder



The Bailey Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart. These records enable the operator to keep fuel burning equipment performing continuously in the zone of maximum combustion efficiency. Excess air may be reduced to the point where combustibles begin to show.

G 40-1

Instruments and controls for power and process

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

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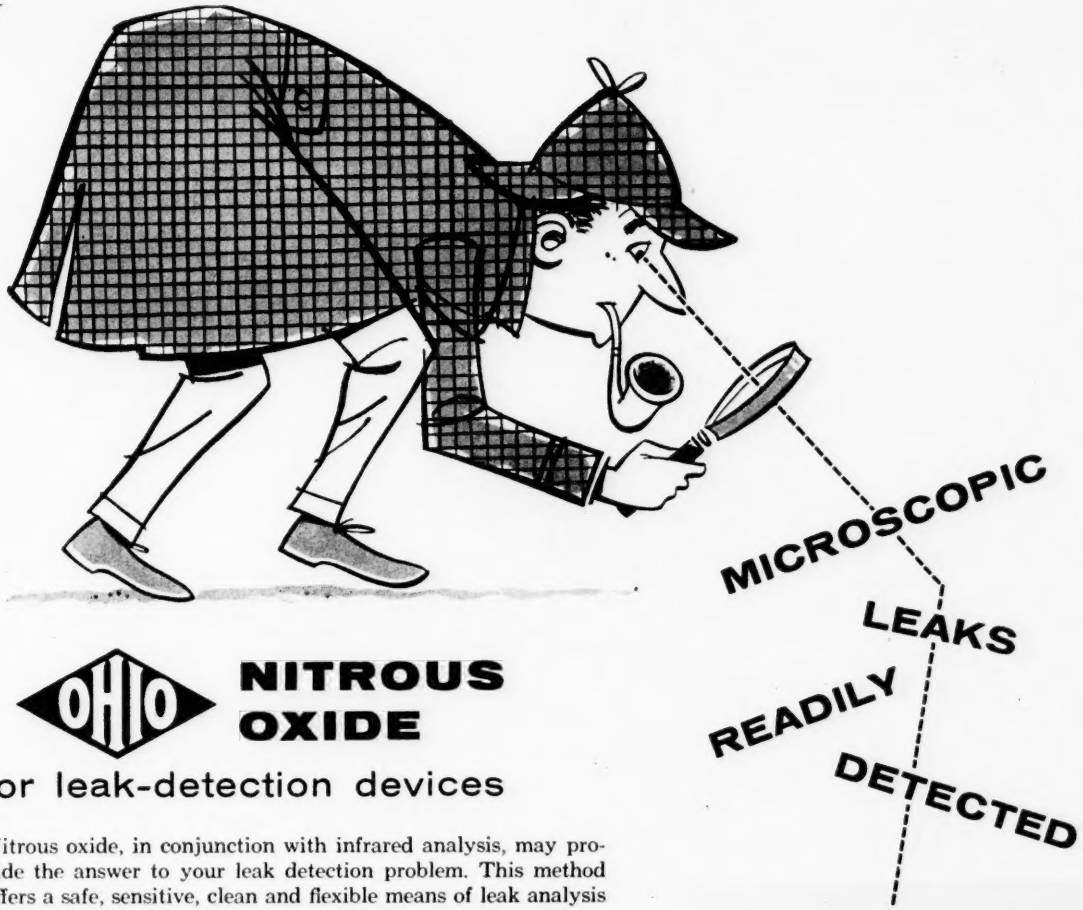

OHIO NITROUS OXIDE

for leak-detection devices

Nitrous oxide, in conjunction with infrared analysis, may provide the answer to your leak detection problem. This method offers a safe, sensitive, clean and flexible means of leak analysis which can be adapted to production line work, as well as single unit testing. Because of its inert properties, nitrous oxide has no effect on components to be tested; and the nitrous oxide infrared method is insensitive to usual atmospheric elements such as moisture, carbon dioxide and hydrocarbons.

Nitrous oxide with infrared determination is now being used successfully in automobile plants and several rubber companies to leak-test air-ride suspension systems and their components. Many other industries are either now — or soon will be — using this method of leak detection. They include such varied applications as: aircraft and missiles, compressors, refrigeration units, process industry piping, tanks, food packaging and air brake systems. May we suggest that you investigate soon the advantages of using nitrous oxide as the detection medium for your leak testing?

Ohio Chemical is the world's largest producer of nitrous oxide. Our 32 branch offices and over 70 warehouse points assure you of nationwide availability.

OHIO NITROUS OXIDE

- ODORLESS AND INERT
- NONTOXIC
- NONCORROSIVE
- NONFLAMMABLE
- ECONOMICAL
- WILL NOT CONTAMINATE TEST PIECES

FREE TECHNICAL AID is available in the use of nitrous oxide for leak detection. For further information, please fill in coupon below requesting the following bulletins:

IA Chemical, Physical and Pharmacological Properties of Nitrous Oxide with Results of Corrosion Tests.

IB Gas Service Equipment for Nitrous Oxide Supply.

"Service is Ohio Chemical's Most Important Commodity"

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Ohio Chemical
OHIO CHEMICAL & SURGICAL EQUIPMENT CO.
Madison 10, Wisconsin
(A Division of Air Reduction Company, Incorporated) AIRCO

Dept. IA-7

Please send me Bulletins IA and IB, described above.

Firm Name.....

Address.....

City.....Zone.....State.....

Your Name.....Title.....

For more information circle **48** on inquiry card.

CRESCENT ARMORED MULTITUBE®

IMPROVED CABLED TUBING

Gives You A Better Job At Less Cost

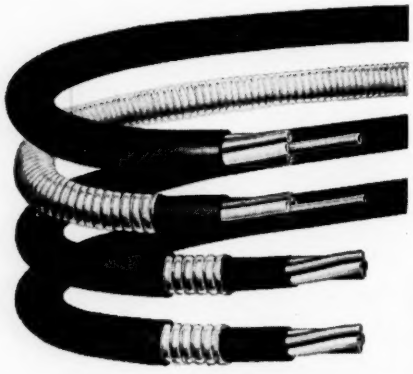
Carriers Air, Gas or Fluid

CRESCENT ARMORED MULTITUBE is a group of 2 to 37 tubes of copper, aluminum, steel or polyethylene **spirally cabled together** and protected by a flexible, interlocked galvanized steel armor, or by a tough corrosion resistant thermoplastic sheath, or a combination of both (see below).

The SPIRAL CABLING of the tubes permits easy bending to a small radius without distortion of the tubes. It can be installed with great saving in time.

Special constructions are available for underground runs. This product is licensed under U. S. Patent 2,578,280.

CRESCENT ARMORED MULTITUBE completely out dates the old method of using single tubes, with users reporting *savings in installed cost of* from two to five times the cost of the multitube. In addition, the MULTITUBE system will result in fewer connections and fittings, lower costs for supports or racks, ease of mounting and less space.



FOUR CORROSION-RESISTANT TYPES

A plastic jacket of polyvinyl chloride over SPIRALLY CABLED copper or aluminum instrument tubing provides complete moisture and corrosion protection for the tubes. Flexible galvanized steel armor in various combinations, as shown, gives maximum protection for permanence. Available in size ¼" O.D. in lengths to 1000 feet in from 2 to 37 tubes.

Plastic Coated Single Tubes, copper or aluminum, should be used to give corrosion protection to all single lines up to the final tube fitting, where trouble from corrosion may occur.

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Trenton 5, New Jersey

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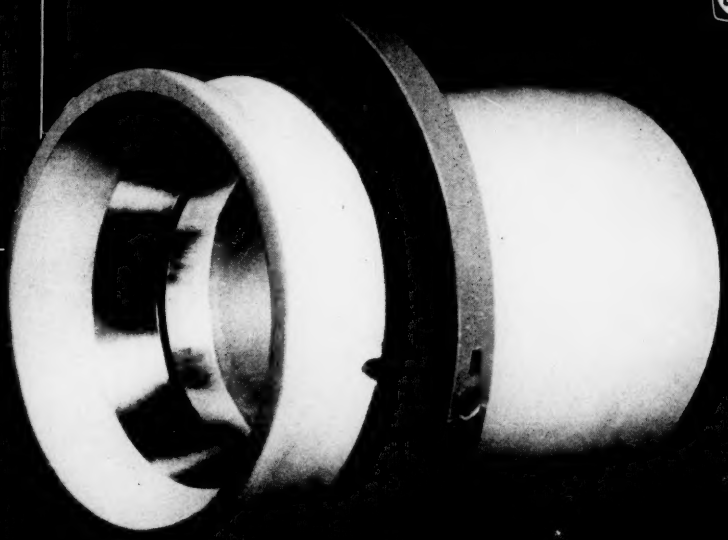
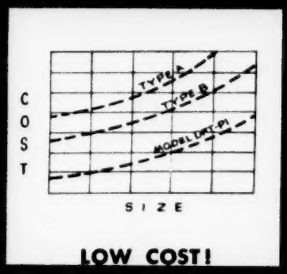


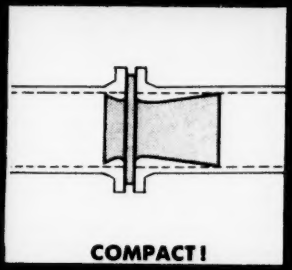
LOW COST

CORROSION-RESISTANT

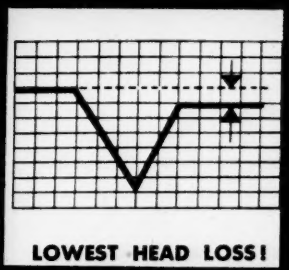
FLOW TUBE!



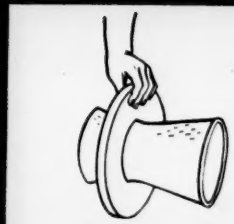
LOW COST!



COMPACT!



LOWEST HEAD LOSS!



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NAME: Builders-Providence Model DFT-PI.

MATERIAL: Made of epoxy or polyester resins reinforced with fiberglas . . . . with corrosion-resistant metallic throat-ring and flange.

INSERT DESIGN: Installs between pipe flanges on process line; no field drilling required; cuts head loss 90%!

ACCURACY: Uncalibrated — within ±1% of actual flow rate; calibrated — within ±½ of 1%. Combined enduring accuracy with absolute minimum head loss.

PERFORMANCE GUARANTEED: Backed by Builders' 65 years of active design and manufacturing experience in the flow meter field.

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☐ Please rush me complete data on this amazing new Plastic-Insert type of Dall Flow Tube.

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Company .....

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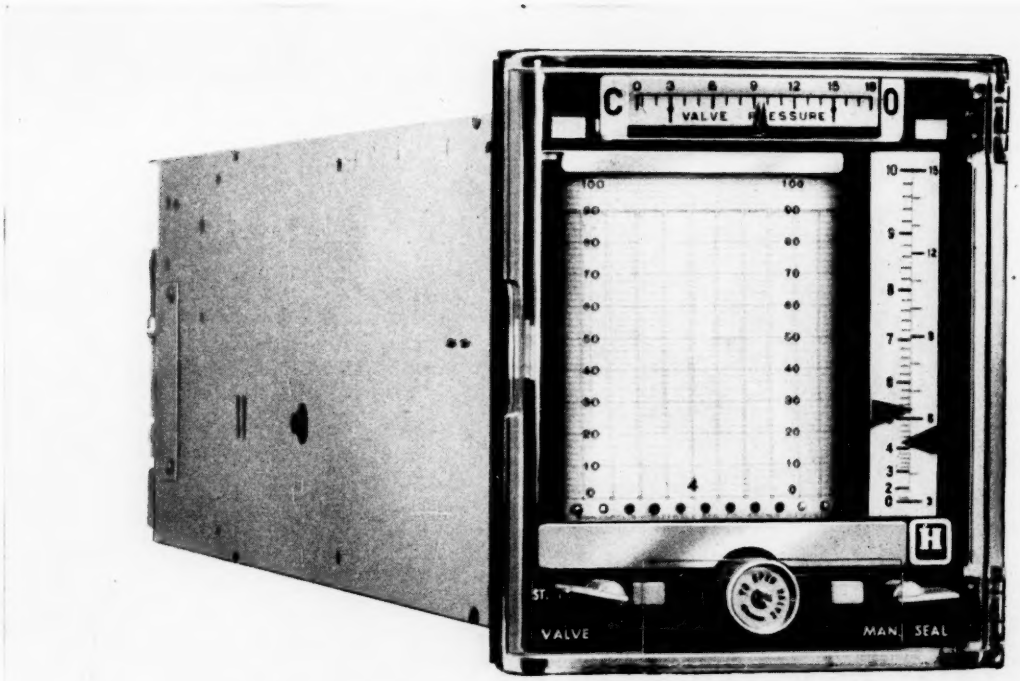

You save in many ways with TEL-O-SET receivers...

today's most advanced miniature pneumatic instruments

Record or indicate any process variables with versatile *Tel-O-Set* receivers. They're the most dependable, economical, and easily-serviced miniature instruments you can buy.

CUT INSTALLATION COSTS

- Startup is safeguarded by wiring and piping case separately . . . keep chassis safe in original carton until startup.
- Quick-connect design makes chassis mounting easy, fast, foolproof.

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- Use any *Tel-O-Set* receiver with any pneumatic force-balance controller.
- Change recorder to indicator and vice versa . . . without changing case or disturbing field connections.

REDUCE PROCESS DOWNTIME

- All working parts can be inspected during operation, without process interruption.
- Zero and span, the only adjustments required, are set from front of panel.

SAVE IN MAINTENANCE

- Separate pneumatic and electric connections—no need for electrician to stand by.
- Linearity built in at factory, requires no attention.

Get complete details on receivers and other *Tel-O-Set* instruments from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

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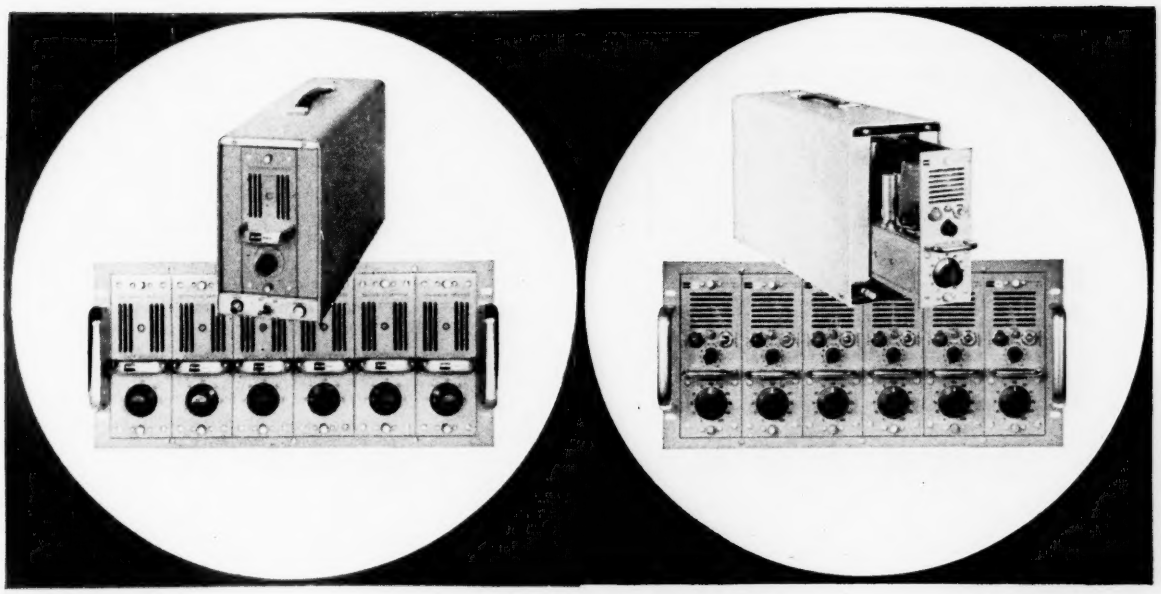
First in Controls

AMPLIFY MICROVOLTS WITH STABILITY... measure strain, temperature, other phenomena, to 0.1% with a KIN TEL DC amplifier



NEW...TRUE DIFFERENTIAL DC AMPLIFIERS ELIMINATE GROUND LOOP PROBLEMS...RESCUE MICROVOLT SIGNALS FROM VOLTS OF NOISE

160 db DC, 120 db 60 cycle common mode rejection with balanced or unbalanced input ■ Input completely isolated from output ■ Input and output differential and floating ■ 5 microvolt stability for thousands of hours ■ 0.05% linearity, 0.1% gain stability ■ Gain of 10 to 1000 in five steps ■ >5 megohms input, <2 ohms output impedance ■ 10 volt at 10 ma output ■ 120 cycle bandwidth ■ Integral power supply

Ideal for thermocouple amplification, the Model 114A differential DC amplifier eliminates ground loops; allows the use of a common transducer power supply; drives grounded, ungrounded or balanced loads; permits longer cable runs; and can be used inverting or non-inverting. The 114A can be mounted in either single amplifier cabinets or six amplifier 19″ rack adapter modules. Price: 114A – $775; six amplifier module – $200; single amplifier cabinet – $125.

WIDEBAND, SINGLE ENDED DC AMPLIFIERS AMPLIFY DATA SIGNALS FROM DC TO 40 KC WITH 2 MICROVOLT STABILITY

±2 microvolt stability ■ <5 microvolt noise ■ 40 kc bandwidth ■ 100 KΩ input, <1 ohm output impedance ■ Gain of 20 to 1000 in ten steps with continuous 1 to 2 times variation of each step ■ ±45 V, ±40 ma output ■ 1.0% gain accuracy ■ 0.1% gain stability and linearity ■ Integral power supply

Millions of cumulative hours of operation have proved KIN TEL Model 111 series DC amplifiers to be the basic component for all data transmission, allowing simple, reliable measurement of strain, temperature and other phenomena. DC instrumentation systems – with their inherently greater accuracy, simplicity, and reliability than AC or carrier systems – are made entirely practical by the excellent dynamic performance, stability, and accuracy of KIN TEL DC amplifiers. Price: 111BF–$575; six amplifier module–$200; single amplifier cabinet – $125.

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WESCON SHOW – Booths 1413, 1414, 1458, 1459.

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A Division of Cohu Electronics Inc.

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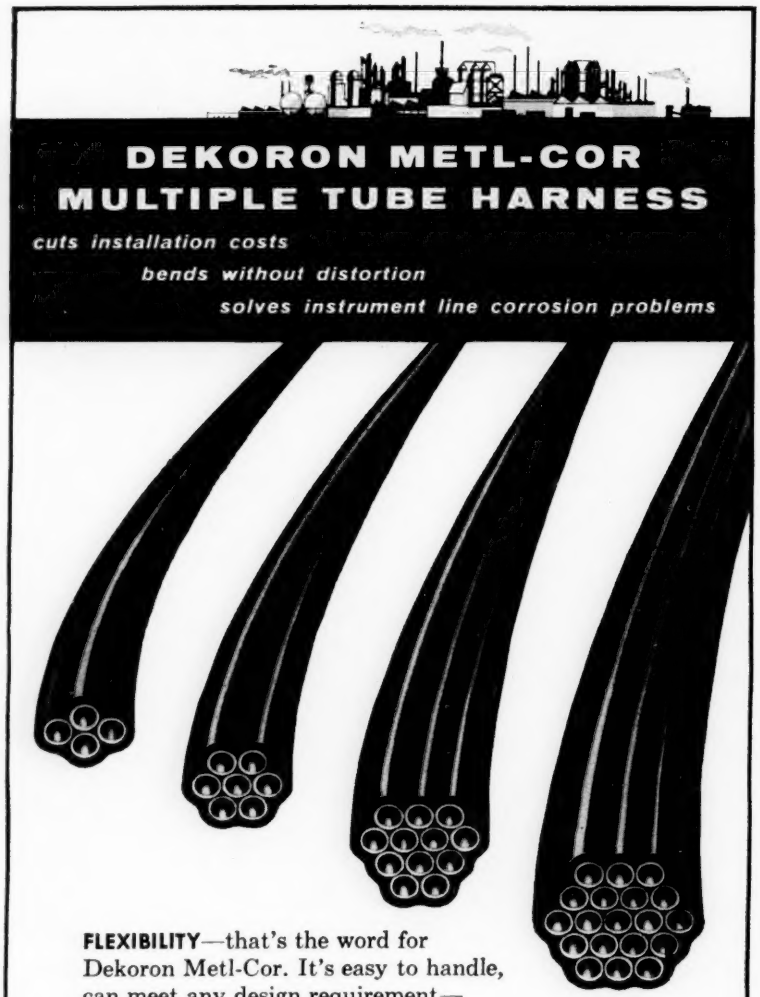

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MULTIPLE TUBE HARNESS

cuts installation costs
bends without distortion
solves instrument line corrosion problems

FLEXIBILITY—that's the word for Dekoron Metl-Cor. It's easy to handle, can meet any design requirement—and it's highly corrosion resistant, too.

FIRST, Metl-Cor's exclusive Extru-Loc construction makes it easy to bend with no tube distortion.

SECOND, the Metl-Cor design is flexible. You can specify Metl-Cor with core tubes in either copper or aluminum . . . in any standard or special OD or wall thickness . . . with almost any number of tubes in each bundle.

MOST IMPORTANT, no matter which type or size you specify—you get all the inherent cost-cutting savings and longer life that you pay for.

AA-7611

Dekoron® products
QUALITY · RESEARCH · SERVICE

SAMUEL MOORE & COMPANY
DEKORON PRODUCTS DIVISION • MANTUA, OHIO

For more information circle **52** on inquiry card.

BIOGRAPHIES of Significance

The significance of Dr. Raymond Jonnard's biography lies in the fact that the many literally vital aspects of medical instrumentation are only now becoming appreciated. Dr. Jonnard, however, has been active in medical aspects of instrumentation for many years. His biography emphasizes the increasing importance of medical instrumentation.

Dr. Raymond Jonnard

Dr. Raymond Jonnard, assistant director of the Medical Laboratories of the Prudential Life Insurance Company of America, has an interesting non-medical background: He has a doctor's degree in science from the Sorbonne, Paris, from which he graduated in 1937. Most of his work, however, was performed in the medical field—as a clinical pathologist, a clinical chemist, and as a pioneer in medical instrumentation.

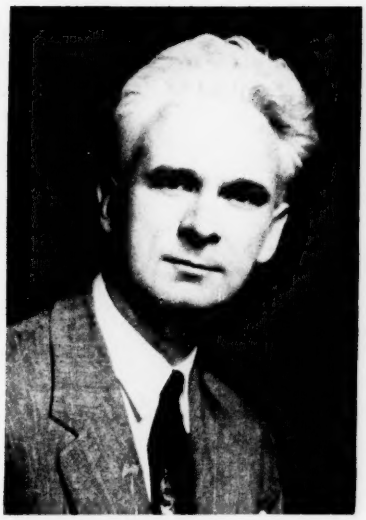
Dr. Jonnard's connection with instrumentation began in Europe, and led to achievements in instrument design which found their recognition in the award of a gold medal by the French equivalent of the Bureau of Standards.

After return from France he taught at Fordham University for one year. Then, from 1939 to 1946, he was head of the Department of Physical Chemistry at the Warner Institute for Therapeutic Research, and handled government research contracts simultaneously.

After the war Dr. Jonnard became a research associate at the New York University College of Medicine, and taught at Rutgers University, Hunter College, and the New York State Institute of Applied Arts and Sciences.

In 1948 he was in charge of the Clinical Laboratories at Paterson General Hospital, where he helped to develop a program of medical and biological instrumentation research under contract from the Office of Naval Research. In Paterson, Dr. Jonnard held the titles of assistant director, clinical pathologist, and chief clinical chemist.

He joined Prudential Life Insurance Company in 1957, where a broad program of laboratory automation is actively pushed under his direction. He keeps in contact with



medical instrumentation developments via technical Society activities, such as the Professional Group on Medical Electronics of IRE, the AAAS, the Assoc. Clin. Chem. and is a fellow-elect of the N. Y. Academy of Sciences.

Dr. Jonnard headed the technical session on Medical Electronics at the Fourth International Automation Congress in New York in June. He has had over 60 scientific publications covering a broad field of interests from analytical chemistry to comparative biology, industrial chemistry and engineering, basic instrumentation research, and scientific philosophy.

Dr. Jonnard reports that he has been reading I&A for 30 years. He will also serve on the editorial staff of the publication *Medical Electronics News*, which will appear late in 1958.

The Automatic Factory
—A Critical Examination

by Stephen A. June
John D. Bardis
Lee H. Lurio
Leonard S. Polaner
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Herbert A. Sklenar
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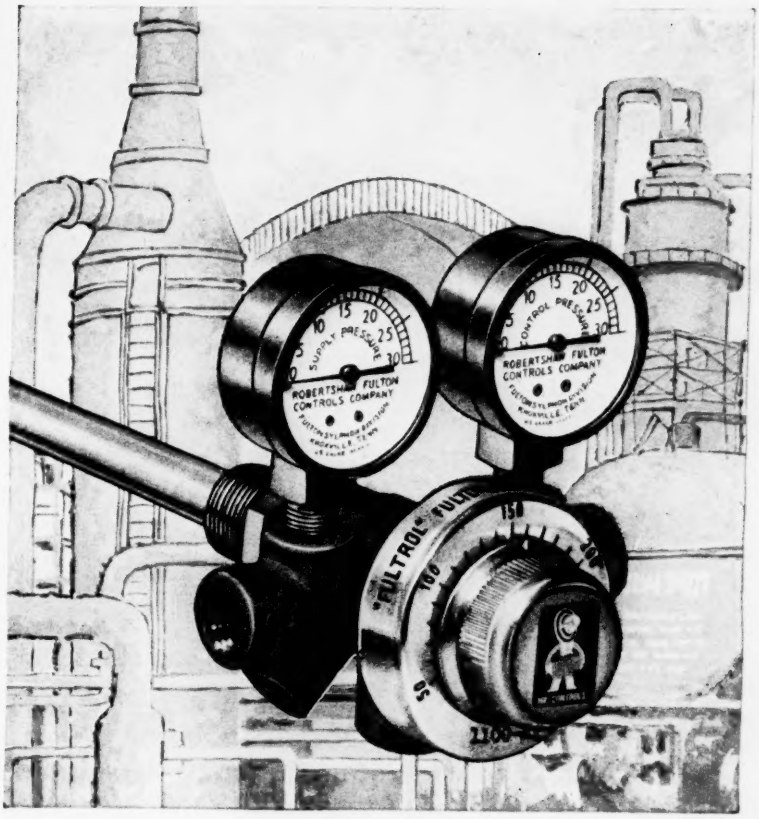
to control process temperature

AT SUCH LOW COST



improved

FULTROL® Pilot Temperature Controller

Whatever your process . . . here's the *best* possible temperature control at the *lowest* possible cost! Simplified, compact unit assures proportional temperature control with fast response . . . and without bulky, complicated hook-ups.

Here's a major improvement recently added . . . at no extra cost to you: Stainless steel bulb and welded bushing replace copper bulb for greater strength and corrosion resistance.

There's a FULTROL model just right for chemical processing, dyeing and bleaching, food processing and many other industrial applications. Available with 200° ranges between -50° and +600°F.

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SALES MANAGERS: You route this memo—

to your ad department and agency—reminding them to plan now to advertise in the 1959 I&A BUYERS' GUIDE

Industry's only instrument-control equipment buying directory, the Guide offers you . . .

- Entree to 23,000 buyers of instrument and automatic control equipment.
- A directory listing equipment, names and addresses of 3,000 manufacturers.
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Reserve your ad space now. Forms close August 15-29—write:

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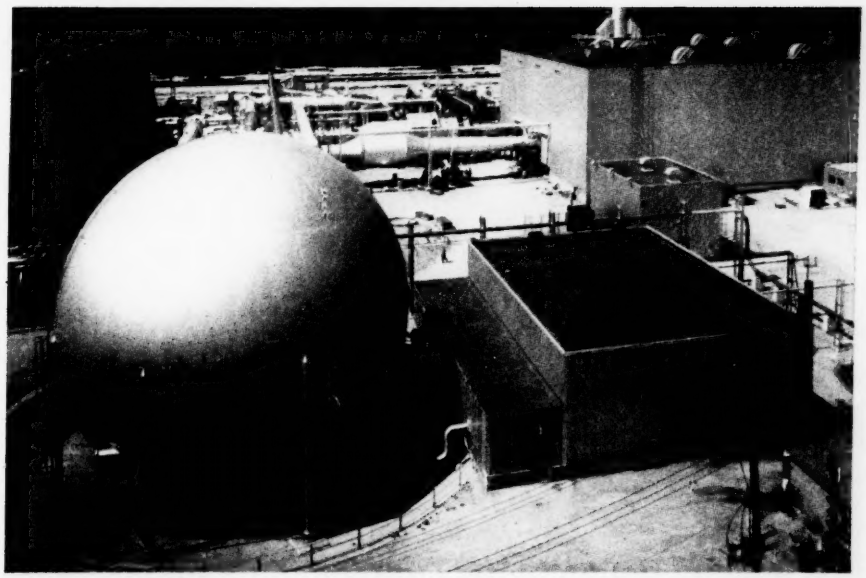


THE E-2 BLOWDOWN TUNNEL at the Arnold Engineering Development Center, Tullahoma, Tennessee. At this wind tunnel center of the Air Research and Development Command, air at pressures up to 4000 psi, stored in a 720' long cylinder, flows into the evacuated sphere through the tunnel which is housed in the building to the right. Construction of the facility is under supervision of the U.S. Army Engineer District, Tullahoma. Three Hagan PowrAmp Model A-2 pressure transducers and two Model 80 electro-hydraulic pilot valves, in conjunction with a Hagan control computer, control stilling chamber pressure.

blowdown wind tunnels with HAGAN CONTROLS

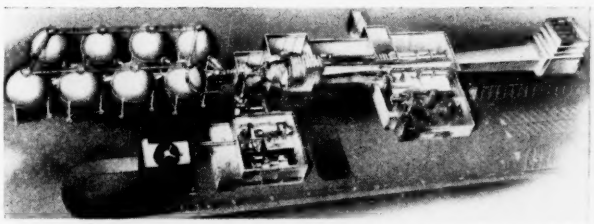
...heavy duty power...laboratory accuracy

Hagan's PowrAmp control components have proved their ability to perform under exacting operating conditions, such as encountered in supersonic wind tunnel installations. Rugged enough to withstand the punishment of heavy usage and fast enough to keep pace with the high speed changes which occur in blowdown tunnels, Hagan control systems have exceeded the accuracy requirements of these tunnels.

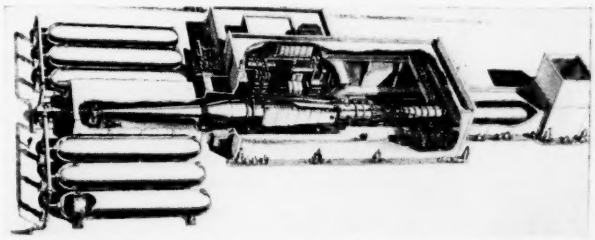
The PowrAmp line includes transducers for most key variables, electronic control computers and pneumatic, hydraulic and electro-hydraulic operators and pilot valves. These high-speed, accurate electro-hydraulic and electronic automatic control devices are available separately, or assembled as pre-planned control systems. Applications include the control of temperature, pressure, flow, density, level and position.

The Hagan PowrAmp line is supplemented by Hagan Kybernetes Division, providing the most advanced techniques in data logging and monitoring applications.

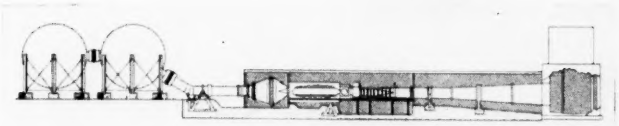
Write for PowrAmp Bulletin M.S.P.-133, or the Kybernetes Bulletins.



NORTH AMERICAN'S TRI-SONIC blowdown wind tunnel at El Segundo, built by Pittsburgh-Des Moines Steel Company, is the largest tunnel of this type in existence. Hagan PowrAmp stilling chamber pressure control has met the performance specifications, controlling velocities up to Mach 3.5.



THE CONVAIR TUNNEL, built by Chicago Bridge and Iron Company, is located at San Diego. Used for both missile and aircraft tests, its operating range is from Mach 0.5 to Mach 5.0. Hagan conducted a complete analog study in designing the control system. Actual operation has exceeded predicted performance.



BOEING AIRPLANE COMPANY'S blowdown tunnel, built by Pittsburgh-Des Moines Steel Company, is also equipped with Hagan PowrAmp controls. Airspeeds as high as Mach 4.2 are produced in the Boeing Tunnel's 4' x 4' test section. A flow-forming nozzle, variable from one to sixteen square feet, controls speed and smoothness of the air. Hagan stilling chamber control equipment includes Model A-2 pressure transducer and electro-hydraulic pilot valve.

HAGAN CHEMICALS & CONTROLS, INC.

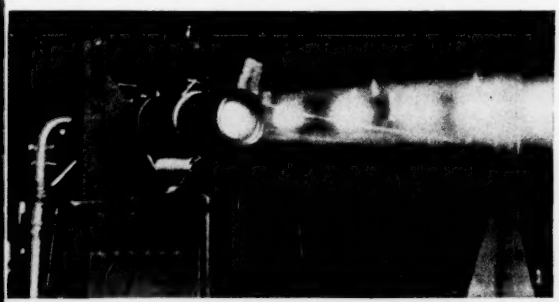
HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO

For more information circle **54** on inquiry card.

When the stakes are high . . .

. . . when extreme instrument accuracy and flexibility are required, Speedomax® instruments really demonstrate their unusual performance capabilities.

For example, engineers at the U. S. Naval Air Rocket Test Station, Lake Denmark, N. J., need extremely flexible recording because data from a number of test cells is centralized in a single compact control room. Here, Speedomax G AZAR (Adjustable Zero, Adjustable Range) Recorders can be easily and quickly adjusted to take outputs of a wide range of thermocouples, strain gages, flow transducers, etc., from any of the test cells. For more than five years, these instruments have been gathering research data on rocket engine propulsion systems. With instrument operation so flexible, maximum use is made of test facilities.



In the central recording room, technicians (left) note run number, test stand number, etc., on recorder charts after rocket (above) is static tested (Official U. S. Navy Photograph).

***"New Horizons"**. L&N's Tech. Pub. ND46 gives data on circuitry and performance characteristics of Speedomax Instruments. Get a copy from your nearest L&N Office or from Leeds & Northrup Co., 4955 Stenton Ave., Phila. 44, Pa.*

LEEDS instruments **NORTHRUP** automatic controls • furnaces

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Russian Exhibit Keynotes Fourth International Automation Exposition

FOR the first time, American instrument men and engineers had an opportunity to examine Russian instruments first hand—at the Russian exhibit of instruments and automatic machinery at the Fourth International Automation Exposition, held June 9-13, 1958 at the New York Coliseum. Most of the 13,000 registrants to the exposition availed themselves of this unique and historic opportunity.

As the pictures here illustrate, the appearance of the Russian instruments is somewhat like that of American counterparts. But here the similarity ends. The guts of the instruments revealed unique engineering and design, emphasizing ruggedness and reliability and the best of modern engineering practice.

The Russians indicated that use of miniatures on graphic panels and use of electronic process controllers is much less general in Russia than in the USA, although such instruments are available. But force-balance transmitters are used widely. A flow transmitter with built-in temperature, pressure and humidity compensation attracted great interest, as did several level indicators and controllers based on cavity resonance and wavelength techniques.

Emphasis in Russia is high on small special-purpose analog computers, and a "Cutting Ratings Computer" was exhibited for determining optimum setups for turning lathes, milling and boring machines in a few minutes.

Russian automation-type machinery exhibited included an automatic machine for threading hexahedral nuts, a winding machine for small toroidal cores, an automatic machine for driving screws into watch balance wheels, an automatic screw machine, and part sorters and counters.

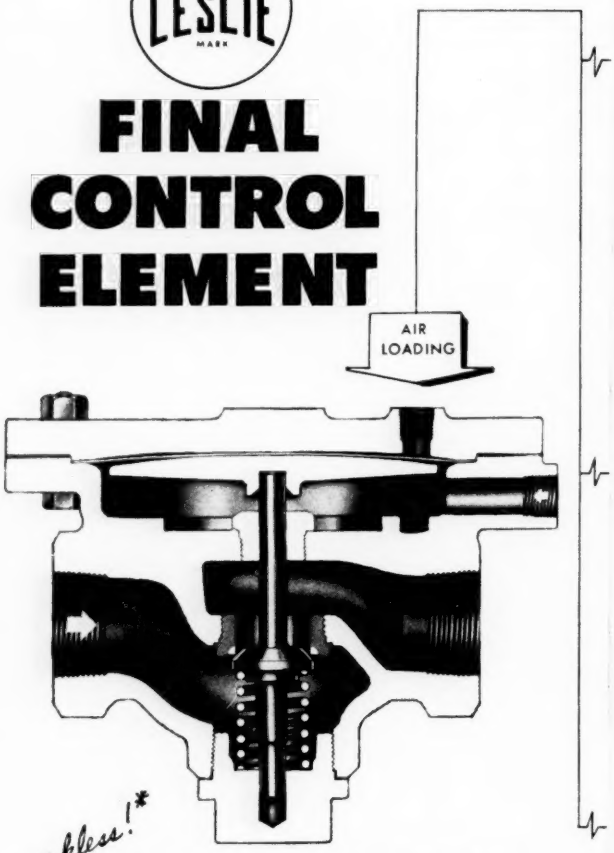
Included among the many Russian instruments exhibited were a magnetic hardness tester, a non-contact radiofrequency liquid-level detector based on the resonance frequency of the volume in a standpipe above the liquid level, precision optical pyrometers with beautiful workmanship featuring 0.5% accuracy to 3000°C; an electronic polarograph for recording either integral (conventional) or differential (derivative) polarograms for both qualitative and quantitative composition measurements; potentiometers and bridges of many types, both automatic null balancing and manual; an *X-Y* recorder; potentiometer and bridge type recording controllers with various modes of control, including electric 3-position, electric proportional, electric proportional plus integral, and pneumatic proportional plus integral; analytical instruments of several different types; pressure transmitters; heat-flow meter; multipoint controllers; multirange volt-ammeters; soil moisture meters; isotope thickness gages; etc. At least four or five novel designs and engineering details attracted the attention of American design engineers.

The Russians admitted in conversation that America has a greater variety and many more differences in design of instruments—traceable to our competitive system. But the level of utilization of instruments seems to be about the same in an equivalent industrial process or laboratory.

RUSSIANS FLEW a complete line of process instruments to the Automation Exposition.

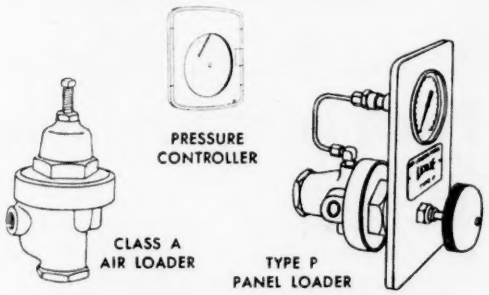
RUSSIAN EXHIBIT included parts handlers, an automatic screw machine, and other automation equipments.

A NEW LESLIE FINAL CONTROL ELEMENT

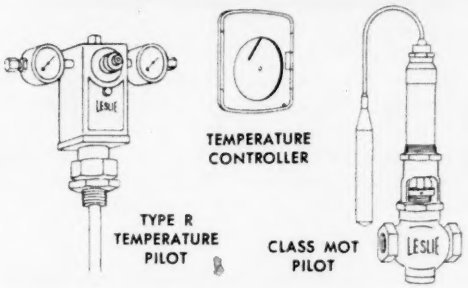


OPERATE THIS CONTROL VALVE
With ANY Of These PNEUMATIC DEVICES

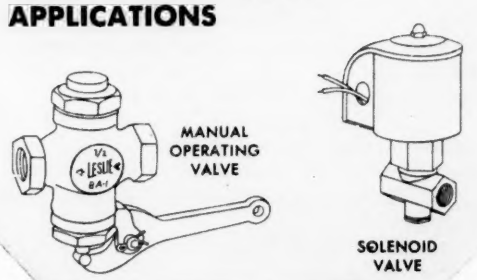
PRESSURE REDUCTIONS



TEMPERATURE REGULATION



REMOTE STOP VALVE APPLICATIONS



packless!* A REALLY VERSATILE CONTROL VALVE — with only two moving parts and a metal diaphragm*

Now, simplified instrumentation combines the simple air loaded, Leslie diaphragm operated valve with various air operated devices. This is the valve that filled a real need when introduced about a year ago, wearing a 3-year guarantee against maintenance in normal pressure reducing services.

This new final control element is gaining wide acceptance for use with a variety of pneumatically operated controllers — simplifying pressure reductions, temperature regulation, remote stop valve applications and many process steam control services.

Ideal for "problem" installations

This control valve is ideal for either continuous or intermittent service and has remarkable immunity to dirty steam. Furnished in cast iron, sizes ½ - 2", it is suitable for any steam service up to 250 psi, 450F, and many fluid services.

It's simple — it's accurate

This Leslie control valve has only two moving parts ... no fussy seals, no stuffing boxes, no small dirt-catching parts; yet, with all its simplicity, it provides uncanny accuracy with its double* feed-back action. It lends itself readily to remote adjustment, too.

More Information

Ask your Leslie engineer to tell you more about this really versatile valve and the simplified instrumentation "packages" now available. You'll find him listed in your classified directory under "Valves" or "Regulators" and eager to come up with new ideas for simplifying pressure, temperature and liquid level control systems.

Send for Bulletin 561-A

* These are the President's comments — even the ad manager didn't know all the fine features!

TRADE LESLIE MARK **REGULATORS and CONTROLLERS**

646 **299 Grant Avenue, Lyndhurst, New Jersey**

For more information circle **58** on inquiry card.

Graphic panels and miniatures are not as widely used in Russia as in the USA, and the new graphic panel of Panellit exhibited at the Automation Show, featuring flexible and lovely Mylar markings, attracted much attention.

The Russians admitted also that their need for analysis of the unit industrial process (in order to apply control theory) is as great—and as undeveloped—as in USA. However, institutions are attacking this problem systematically in Russia. Although some private USA firms are attacking this problem, American users cannot agree to the extent to which this is actually being done (some declaring that little if any such analysis is being effectively undertaken). The Russians were extremely interested in the Quarie "Process Characteristic Analyzer" revealed at the Automation show. They stated that in two years they will have instruments for obtaining the response characteristics of industrial processes.

The Russians sought answers to many questions also being asked by Americans—for example, just how is the economic value of a "computer-in-control" situation realized? After detailed discussion on this question, the Russians indicated that the gap between theory and practice as applied to computers in control is as great in Russia as in the USA.

Many other similarities in situation emerged from discussion with the Russians. For example whereas instrument engineers (professionals) receive about the same pay as other engineering types, instrument maintenance men receive less pay than pipefitters.

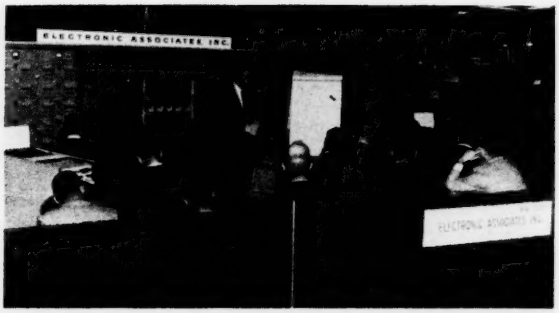
Russian plant instrument departments not only install and set up all controls, they also select all control adjustments. The head of a plant instrument department thus must be a good instrument engineer: he has full responsibility for setup as well as operation.

Among the significant differences in practice, the Russians periodically send instrument men for all-expense-paid two-month courses at Moscow University to assure their familiarity with late techniques. Further, technical books in Russia are much cheaper than in the USA. However, the Russians admit to the same problem with regard to getting the books read and understood.

Standards are set in Russia by a Government Standards Committee, which accepts the recommendations of Advising Institutes. Once a standard is approved, however, it must be used by everybody. It is of interest to note that no electrical signal standard has been set for transmitter signals (corresponding to the 3-15 psi pneumatic signal accepted in Russia and in the USA). Two are under consideration—(1) dc voltage of 0-100 millivolts and (2) any electric signal, current or voltage, followed by appropriate receivers.

IN THE MORNING the exhibit functioned as a classroom, and in the afternoon as an exhibit.

FIRST DIGITAL computer for process control (RW-300) was both exhibited and taught in classroom clinics.



ELECTRONIC ASSOCIATES teaches analog computer fundamentals in clinic classes.

PANELLIT'S NEW graphic panel with Mylar finish and markings attracted great interest.

ATTENDANCE AT ALL technical sessions was high, including data acquisition and reduction (below), medical instrumentation, military automation, control valves, etc.

Use of standard components (blocks) is actively pursued under a program known as the "aggregate principle," which should eventually assist the application of more theory in instrument situations.

Clinic Sessions

The second unique feature of the Fourth International Automation Exposition was the powerful clinic concept, whereby the exhibit functioned as a classroom in the morning and as a conventional exhibit in the afternoon. (see illustrations). More than 2000 persons took advantage of the opportunity to learn about the principles and practice of the most modern automation equipments via these clinic sessions. Many of these will be published in the feature article section of *INSTRUMENTS AND AUTOMATION*.

Technical Sessions

More than 1500 attended the technical sessions on instrument education, military automation, materials handling, measurements, control valves, medical instrumentation, product design, weighing, data acquisition and reduction, and cybernetics. The large attendance at the cybernetics session on "learning processes," "cybernetic machines," and "cybernetic entropy and organic evolution" is indicative of the pulling power of these fundamental, basic, theoretical subjects.

Disclosures

As at all trade expositions, most exhibitors had new and interesting equipment and components to disclose.

The building-block concept was advanced one more step by the introduction of a line of "Digitrol" blocks by Electro Precision Corporation of Arkansas, with blocks for not only preamplifiers and decade counters but also triggers, power amplifiers, and digitizing servo motors, thus increasing the possible combinations of elements.

Veeder Root introduced a new line of counting "packages" and predetermined counters.

Wang Laboratories introduced a punched tape reader that reads a block (20 lines) at a time.

Several new positioning systems and machine tool control systems were introduced, as were several new instruments for level monitoring and control. DuMont Laboratories introduced a new comprehensive laboratory oscilloscope that features calibrated plots on both axes plus an internally triggered "electronic shutter" for beam brightening during *X-Y* plots.

Further reports on the Automation Show will appear in future issues of I&A; these will include a report of the meeting that discussed the formation of a Systems Engineering Council, and also the papers delivered at the technical sessions.

Circle **57** on inquiry card. ⟶

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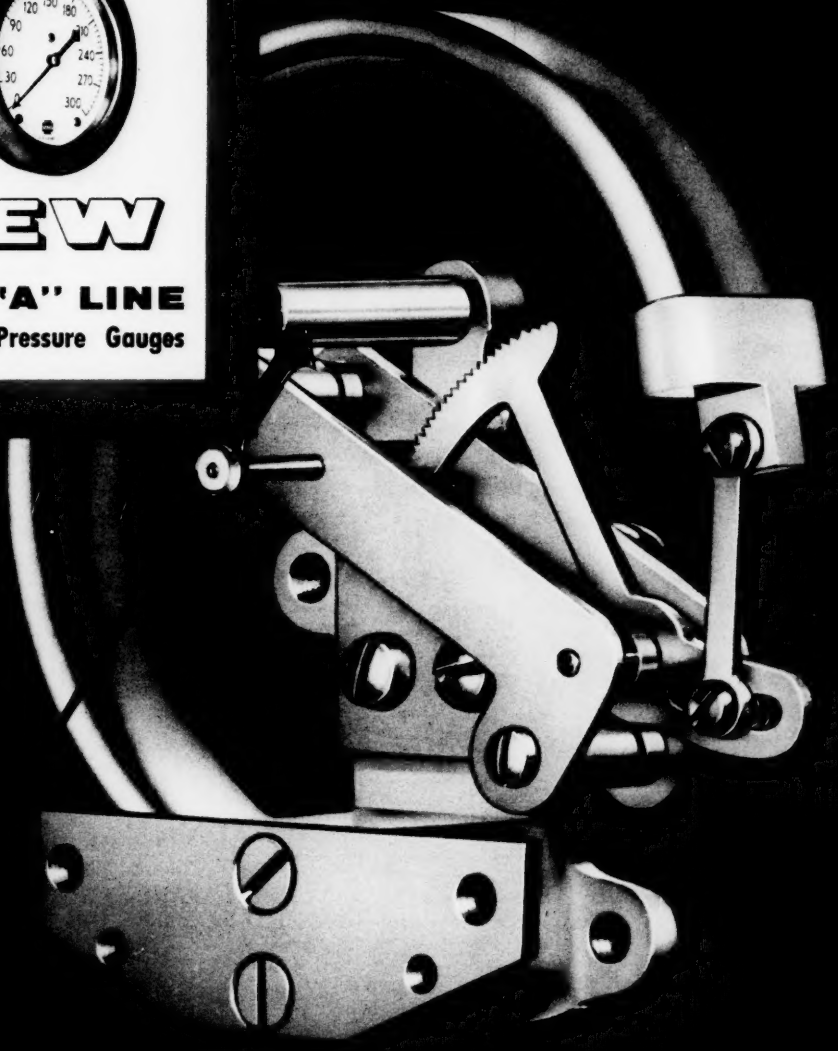

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	FIGURE NUMBER	5001	5002	5003	5004	5005	5006	5007	5009	5021	5022	5023	5024	5025	5026	5027	5029	5041	5042	5043	5044	5045	5046	5047	5049	5061	5062	5063	5065	5067	5069	5081	5082	5083	5084	5085	5086	5087	5089
AVAILABLE SIZES	3½"	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
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	Aluminum, Front Flange			•								•								•								•						•					
	Brass, Back Flange				•								•								•								•						•				
	Cast Iron, Back Flange					•	•							•	•							•	•							•						•	•		
	Cast Iron, Front Flange							•								•								•							•							•	
	Phenolic, Turret								•								•								•						•								•
RING	Steel Peaked, (Slip)	a				•				•			•					•				•				•			•			a			•				
	Aluminum Peaked, (Threaded)		•								•								•								•						•					
	Steel, (Hinged)			b				•				•				•				•				•				•						b				•	
	Brass Peaked, (Threaded)				•		•						•		•						•		•												•		•		
	Steel, (Snap)								•								•								•						•								•
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*Except 3½" size. **On 5090 series only, a stainless steel movement is used for 3½" size.

(a) Steel peaked slip ring, except for 12" where cast aluminum slip ring is furnished.
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TWO NEW OHMITE® RELAYS

with exclusive "Molded Module"* contact springs

exceptional sensitivity for small size

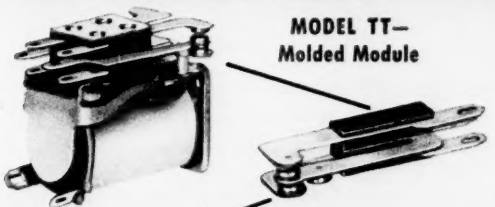
designed to meet aircraft, military, and industrial applications

*Patent applied for

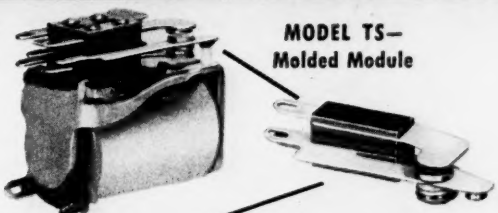
The new Models TT and TS relays incorporate several design innovations that make them ideal for aircraft and industrial applications at high ambient temperatures. Both relays are lightweight, yet rugged. Paramount among the design innovations is the revolutionary "Molded Module" contact spring construction. The "module" is a standard, single-pole, double-throw spring combination molded into a single compact assembly. As many as six modules can be incorporated into a relay to provide a maximum six-pole, double-throw combination. With the springs rigidly held in a matrix of tough plastic, alignment of the springs is assured. More accurate alignment of all the subcombinations (modules) on the relay is possible, and adjustment of the individual contact springs is easier and more permanent. Diall Phthallate, the molding material, is capable of withstanding temperatures to 400°F.

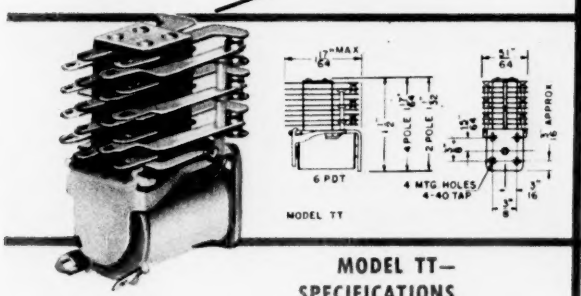
A contributing factor to the remarkable sensitivity of these relays is the design of the armature retaining guard to minimize undesirable heel gap. A wide variety of hermetically sealed enclosures is available.

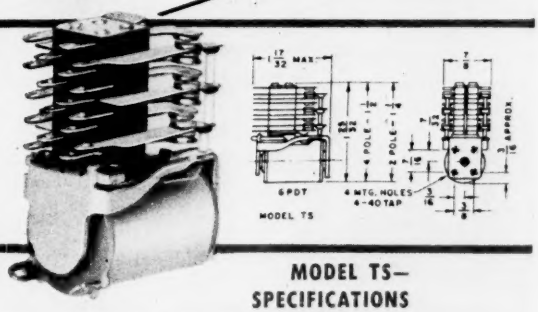
MODEL TT—
Molded Module



MODEL TS—
Molded Module







MODEL TT— SPECIFICATIONS

COIL WATTAGE: Rated nominally at .150 watt per pole at an ambient temperature of 20°C.

COIL OPERATING VOLTAGE RANGE: To 115 VDC.

CONTACT RATINGS: Up to 5 amperes at 115 volts AC or 32 volts DC noninductive, with standard contact material, palladium. Other materials can be supplied.

CONTACT COMBINATIONS: Standard combinations are DPDT, 4PDT, and 6PDT (maximum). Others can be furnished.

WEIGHT: Approximately 2 ounces for 4PDT relay.

MODEL TS— SPECIFICATIONS

COIL WATTAGE: Rated nominally at .250 watt per pole at an ambient temperature of 20°C.

COIL OPERATING VOLTAGE RANGE: To 115 VDC.

CONTACT RATINGS: Up to 10 amperes at 115 volts AC or 32 volts DC noninductive with standard contact material, silver-cadmium oxide. Other materials can be supplied.

CONTACT COMBINATIONS: Standard combinations are DPDT, 4PDT, and 6PDT (maximum). Others can be furnished.

WEIGHT: Approximately 3 ounces for 4PDT relay.

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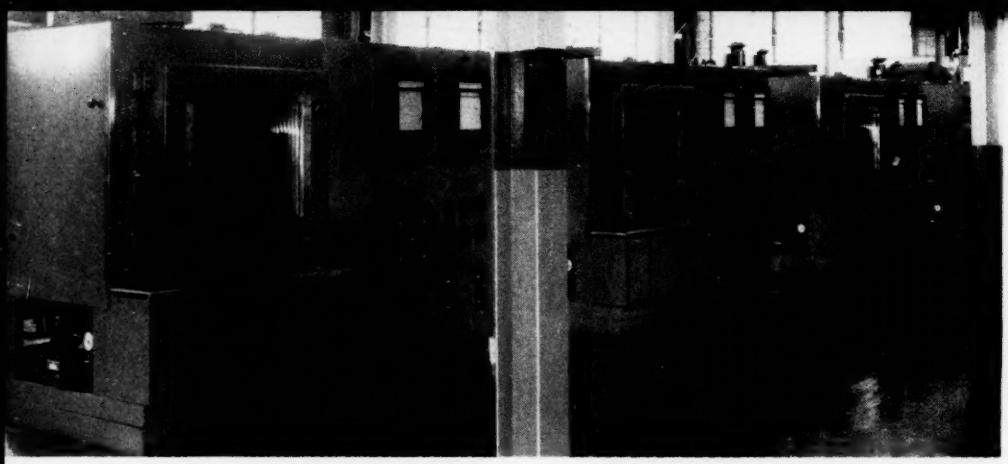


MURPHY AND MILLER test equipment at the Western Electric Company. Leeds & Northrup instrumentation was used.

New Concepts

SEVERAL accepted techniques and practices in the field of environmental testing are being questioned today. Much that is performed as standard practice may be not only inadequate but even detrimental to the ultimate objective—reliability.

The first concept under attack is the Production Environmental Testing (PET) concept whereby all production units are subjected to moderate environmental testing, under the assumption that the shortest-lived units will fail, leaving only the rugged and long-lived units. This concept has been attacked by Robert Lusser of Redstone Arsenal*. Mr. Lusser points out that the concept is based on an "infant mortality" analogy to human beings, but that inanimate objects do not have "infant mortality," and production environmental testing simply reduces the life of the production item. In place of production environmental testing, Mr. Lusser suggests that only testing to failure has real meaning, and testing samples to failure to establish the eventual cause of unreliability is better practice than "PET."

The second concept being questioned is that of testing reliability under environmental conditions that do not include all variables simultaneously. In other words, a component can be proved insensitive to vibration and temperature independently, but the component may be sensitive to *both* simultaneously.

This is leading, today, to the adaptation of test chambers and techniques with combination environments.

Although test equipments, chambers and techniques have been developed for temperature, pressure, humidity, sand, dust, fungus, corrosion, immersion, explosion, rain, sunshine, vibration, acceleration, fuel resistance, endurance, shock, fatigue, radio interference, and noise resistance, the field of combined environments plus function remains an exciting one with many surprises predicted. Work is underway on this problem, as the illustrations herein show.

Other areas of increasing importance include very-low-temperature testing (cryogenics), high-force vibration, and random complex-waveform vibration. Facilities and equipments for such work are now available.

The following tables offer sources for the basic environmental tests and equipments. The specific products of these companies will be surveyed in a future issue of *I&A*.

*Environmental Quarterly, Vol. 4, No. 2

TABLE 1—TEST CHAMBERS

Alpha Electric Refrigeration Co.—Low temperature cabinets.

American Instrument Company—Sub-zero test cabinets.

American-Marietta, Guardite Div.—Environmental test chambers.

American Research—Test chambers, including temperature, humidity, dust, altitude, fungus, etc.

Associated Testing Laboratories, Inc. Manufacturing Div.—Low and high temperature-humidity chambers, multichamber units, explosion test chambers, radial acceleration units, salt spray chambers altitude-temperature chambers, rain and sunshine chambers, sand and dust chambers, fungus resistance chambers, temperature-vibration chambers.

Atmosphere Control Company—Moisture-vapor transmission cabinets.

The Baker Co.—Dust-free work benches and rooms.

Bemco—Test chambers, including pressure, temperature, salt spray, fungus, explosion, etc.

Blue M Electric Company—Relative humidity chambers, including programmed temperature and humidity. Also ovens and furnaces.

Boder Scientific Co.—High and low temperature utility and laboratory baths.

Bowser—Chambers for temperature, sand, dust, etc.

Burrell Corp.—Thelco line of ovens and incubators.

G. F. Bush Associates—Weathering testers, light-fading testers, ozonators.

Cincinnati Sub-Zero—Test chambers.

Consolidated Electrodynamics, Rochester Div.—Vacuum apparatus.

Cook Electric Co., Nucledyne Div.—Stratosphere chambers, environmental chambers, combination environmental-vibration chambers.

Dale Products—Constant-temperature ovens.

Delta Design Engineers—Portable temperature test chambers.

Development Engineering Co.—Salt-spray fog test chambers, high and low temperature humidity chambers, fungus test cabinets, and "servo unit" providing controlled air for use in conjunction with tensile tester impact tester, etc.

ENVIRONMENTAL LAB of Litton Industries. Altitude-temperature-humidity chamber in foreground has instrumentation by Minneapolis-Honeywell and Bristol. Second chamber is low and high temperature unit. Third chamber is humidity chamber; fourth chamber (background) is salt-spray unit. All chambers were made by Bemco.

in Environmental Testing

Environmental Equipment Corp.—Test chambers for humidity-temperature-altitude, sand, dust, fungus, rain, sunshine, explosion.

Fisher Scientific Company—Isolation chambers, constant-temperature ovens.

Garrett Corp. AirResearch Mfg. Div.—Specialized environmental testing chambers.

Grieve-Hendry—High-temperature ovens.

Harris Refrigeration—Test chambers.

C. I. Hayes—High-temperature high-vacuum furnaces for heat treatment.

Hieatt Engineering Company—Temperature-humidity-altitude test chambers.

International Radiant—Test chambers.

Labline, Inc. (including Hudson Bay Div.)—High and low temperature test chambers. Also constant temperature baths, test chambers for temperature and humidity programs, ovens, shaking baths.

Mantec Inc.—Temperature test chambers.

Murphy & Miller—Test chambers, including temperature, humidity, fungus, etc.

National Appliance Co.—Ovens.

NRC Equipment Corp.—High-vacuum components and systems, including double-bell-ultra-high-vacuum systems.

Schaar and Company—Anaerobic incubator chambers.

Scientific Glass Apparatus Co.—Thelco line of ovens and incubators.

Soiltest, Inc.—Laboratory baths, ovens, drying chambers, including Blue M line.

Standard Cabinet—Test chambers for all environmental conditions.

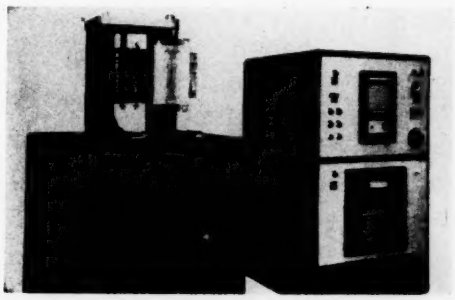
Statham Development Corp.—Test chambers featuring portability and economy, for temperature, pressure, humidity.

F. J. Stokes Corp., Vacuum Equipment Division—Vacuum chambers and storage carts. High-vacuum pumping systems.

Temperature Engineering Corp.—Temperature and vacuum chambers, including vacuum-drying systems.

Tenney Engineering Co.—Temperature-humidity-altitude chambers, low-temperature chests, chambers with two separate environments, rain and sunshine chambers, vacuum test chambers, temperature-pressure-humidity chambers in combination with vibration test equipment, explosion chambers, sand and dust chambers, salt fog corrosion chambers, humidity corrosion chambers.

Webber Corporation—Sub-zero freezing test chambers. Also high and low temperature cabinets.



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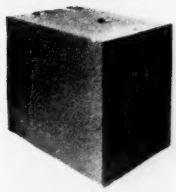

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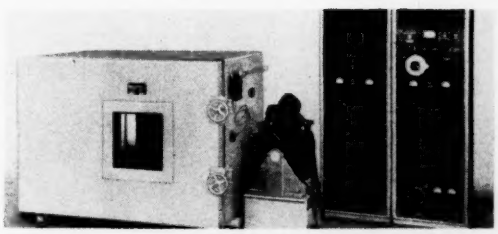
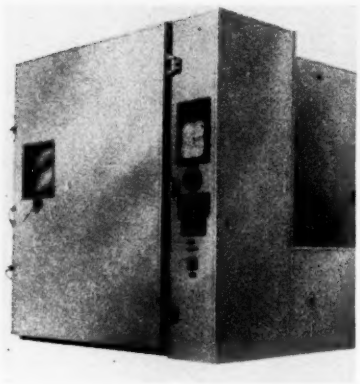


COMBINATION TECHNIQUES are used in these three units. At the top, steels used in gas turbine buckets under environmental conditions which simulate both high temperatures and dynamic loads are tested in this Baldwin-Lima-Hamilton Model SF-4 Fatigue Machine. B shows Statham RA-2 Rotary Acceleration Generator with rotary accelerator in a controlled environment. C shows chamber of Associated Testing Laboratories for high-temperature or low-temperature vibration.



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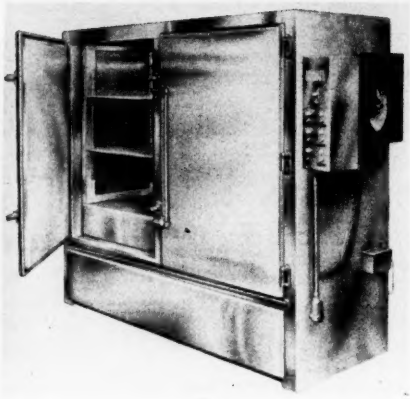

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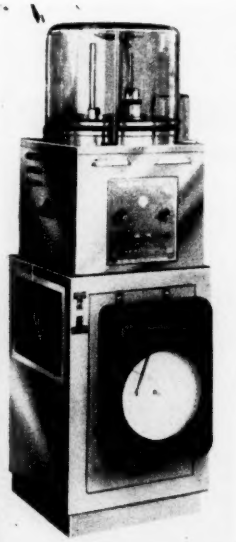

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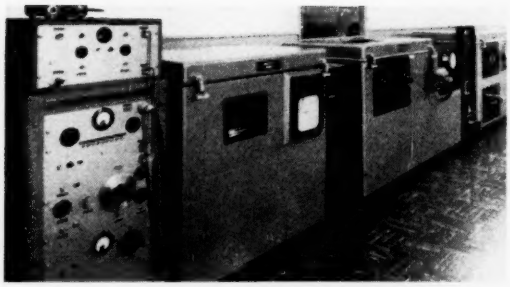

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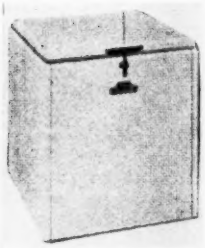

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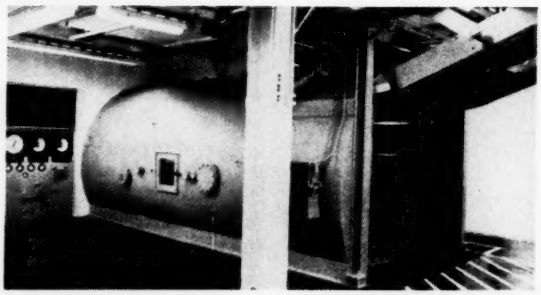

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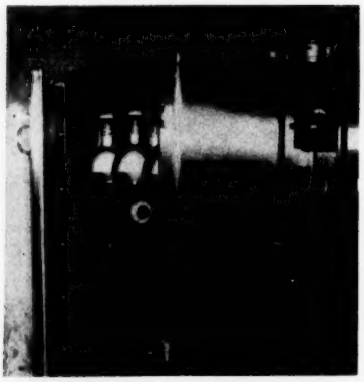

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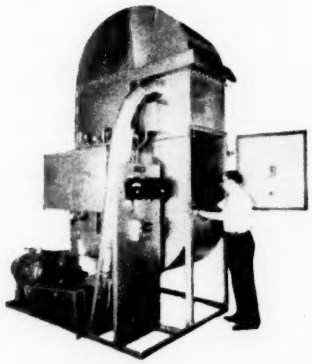


I

Typical chambers show the many features available:

A. Salt-spray fog test chamber of Development Engineering Co.

B. Labline "Environ-Cabs." developed in cooperation with Hudson Bay Co. division of Labline, Inc., provide four conditions of operation—(1) Constant dry bulb with constant humidity; (2) constant dry bulb and varying humidity, (3) varying dry bulb and constant humidity, (4) varying dry bulb and varying humidity.

C. Statham TC-5 test chamber controls within $\pm\frac{1}{2}$°C over range from −70 to +320°C. Special trays accommodate resistors, diodes, etc.

D. Blue M Electric Co. "Vapor-Temp" with mechanical refrigeration controls both dry bulb temperature and relative humidity.

E. "Packaged Laboratory" for environmental testing of missile/aircraft electronic components, delivered to Ratigan Electronics by Mantec Inc., especially designed for PET (Production Environmental Testing). L. to R.: automatically-programmed humidity-temperature-vibration chamber; altitude-temperature chamber with removable plenum; JAN-S-44 shock machine; two high-low temperature chambers.

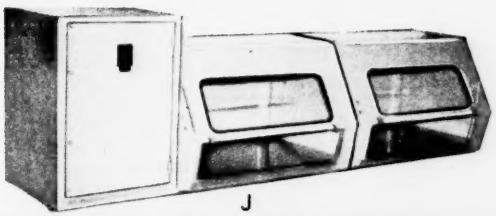
F. Low temperature cabinet of Alpha Electric Refrigeration Co. has range from −120 to +300°F.

G. Temperature-humidity-altitude test chamber of Hieatt Engineering Co., installed in aircraft plant.

H. Rain and sunshine chamber of Tenney Engineering.

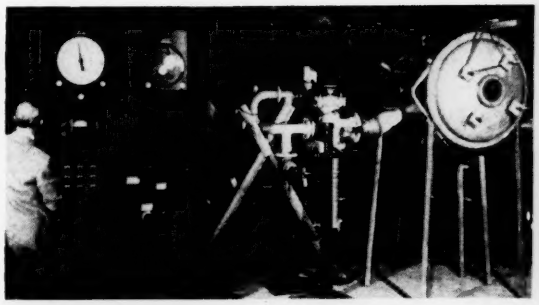
I. Sand and dust chamber of American Research Corp.

J. "Sterilshield" work benches of The Baker Co., Inc.



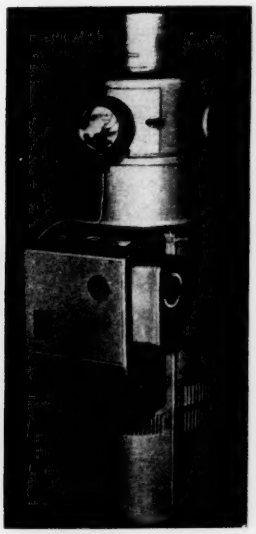
J

K. Vacuum chamber, pumping system and control panel furnished to a manufacturer by NRC Equipment Corp.



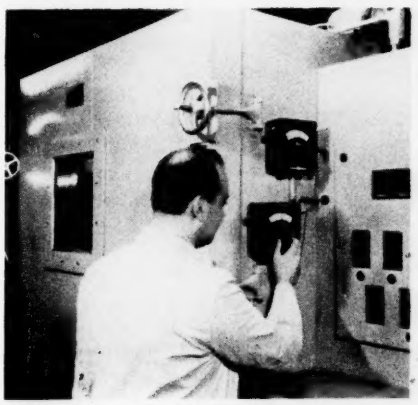
K

L. G. F. Bush Associates' weathering tester "Model WPL394 Xenotest."



L

M. 32-cu-ft environmental test chamber of Associated Testing Laboratories is controlled by the two Fenwal Series 549 Controllers.

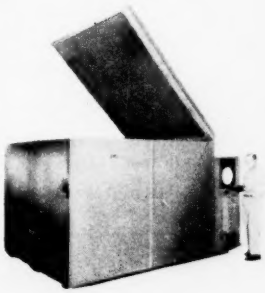


M

N. This test chamber of Douglas Aircraft's Tulsa plant simulates altitude, weather and speed. Fischer & Porter supplied the instrumentation.

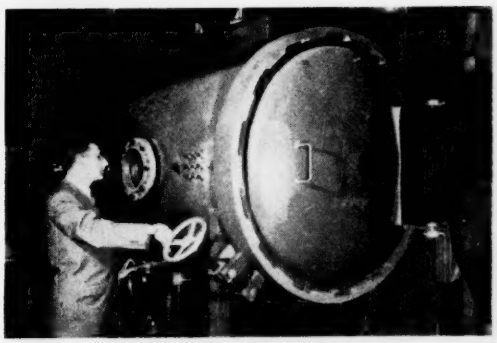
N

O. Webber cold chamber built for aircraft engine manufacturer.



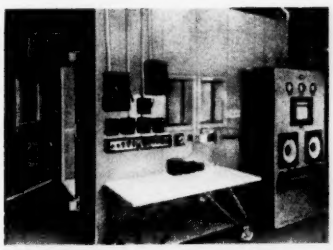
O

P. Tenney Engineering explosion chamber.



P

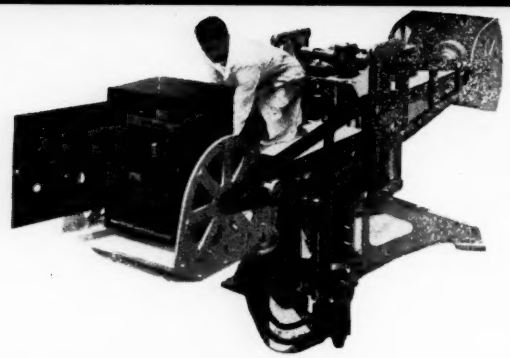
Q. Bowser prefabricated-panel-type walk-in unit for low-temperature and humidity testing. Instrumentation is by Brown (M-H).



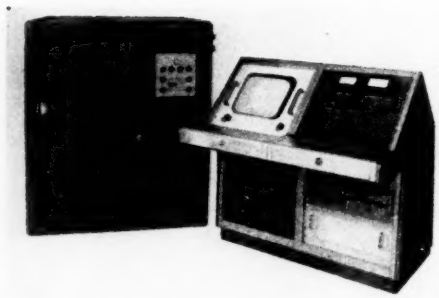
Q

R. Temperature and humidity chamber of International Radiant Corp., with controller maintaining desired conditions. Cam programs set point. Instrumentation is by Brown (M-H).

R



A



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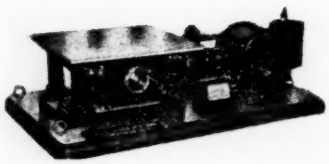
C



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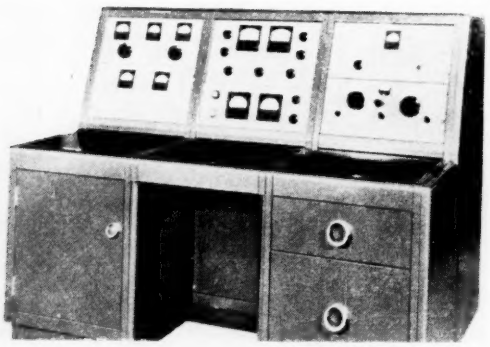
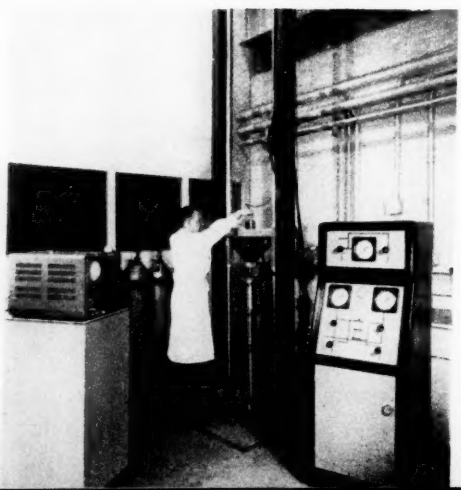


E



F

Vibration and acceleration equipments are available for rotary or linear motion, with sine wave or random complex waveforms:

A. Genisco G-Accelerator for rotary acceleration tests.

B. Baldwin-Lima-Hamilton has developed this dynamic testing machine which tests rubber engine mounts at a constant energy input level. Automatic controls vary the vibratory force so that the sum of spring energy and damped energy is at all times constant.

C. Centrifugal acceleration tests of transistors can be made on this unit offered by Custom Scientific Instruments, Inc.

D. Assemblies up to 150 lbs can be vibration fatigue tested at from 10 to 60 cps on this All American Tool & Mfg. Co. Tester.

E. 1200-force-pound sine-wave vibration system of Ling Electronics.

F. Three-inch Hyge shock tester of CEC with Hughes Products Memoscope-oscilloscope.

Sources for vibration, acceleration, fatigue, shock and strain testing equipments are listed in Table 2:

TABLE 2—VIBRATION, ACCELERATION, FATIGUE, SHOCK AND STRAIN EQUIPMENTS

All American Tool & Mfg. Co.—Vibration and fatigue machines.

American Machine Tool & Mfg. Co.—Fatigue testing machines.

Baldwin-Lima-Hamilton Corporation—Strain, stress, load and fatigue simulation, including simulation under high-temperature environments.

Barry Controls—Shock testers.

Calidyne Company—Vibration and shake tables.

John Chatillon—Shock testers.

Consolidated Electrodynamics Corp.—Shock testing machines.

Custom Scientific Instrument, Inc.—Centrifugal tester for transistors.

Genisco, Inc.—Centrifuges (G-Accelerator) for testing components and systems under simulated operational g-loading; also shake tables.

JAN Hardware Manufacturing Co., Inc.—Shock testing machines.

L. A. B. Corp.—Vibration and shock simulators. Package testers.

Ling Electronics—Vibration testing systems, both sine wave (Sine-O-Matic) and random complex-wave.

Massa Laboratories—Shock testing machines.

MB Manufacturing Co.—Vibration excitation machines.

Rucker—Centrifuges.

Schaevitz Engineering—Rotary acceleration testers. Also tension and compression testing.

Telectro Industries—Shock testers.

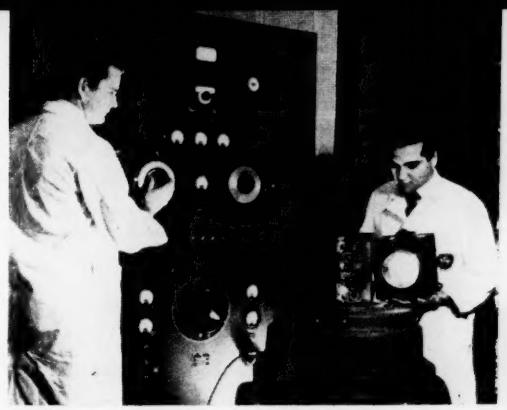
Wyle Manufacturing Corp.—Hydraulically powered "Hydra-shaker" vibration excitation systems up to 45,000 blocked force (W-4500 can shake a 3000-lb specimen at 15 g at 100 cps.)

Test facilities offer almost all types of environmental testing equipments.

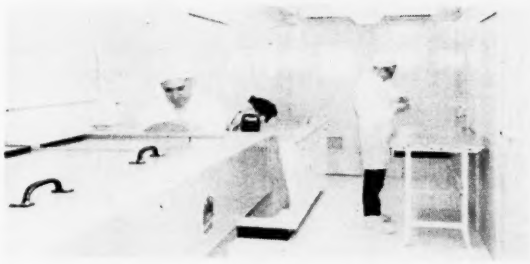
A. Shows search at United States Testing Co. for resonant points in a high-frequency vibration test, using an MB vibration test unit.

B. Electronic assembly within high-low temperature and humidity chamber at United States Testing Company.

C. Shows new mobile (trailer) Lox-cleaning facilities which will supplement Wyle Laboratories' facilities at El Segundo and at Wyle's new high-low cryogenes testing plant at Norco, Calif. It will also be used at customer's plants and test sites.



A



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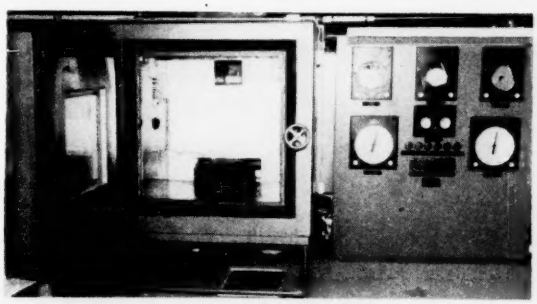


C

TABLE 3—TEST FACILITIES

Acton Labs—Complete environmental test facilities.

Aerotest Laboratories—Test facilities for temperature, pressure, corrosion, fuel resistance, salt spray, humidity, fungus, sunshine, acceleration, vibration, sand, dust, rain, radio interference and functions. Also flow testing of missile fuels and oxidizers.

Associated Testing Laboratories, Inc., Environmental Testing Laboratory—Facilities for temperature, humidity, pressure, explosion, acceleration, corrosion, rain, sunshine, sand, dust, fungus, and combination-function testing.

AVCO Research and Advanced Development Division, Environmental Laboratory—Facilities for testing programs, involving shock, vibration, acceleration, salt spray, sand, dust, temperature, altitude, humidity, fungus, noise.

Avion—Facilities for environmental testing.

Cook Electric Co., Inland Testing Laboratories Div.—Facilities for complete environmental testing.

Electrical Testing Labs—Environmental facilities.

Horkey-Moore—Facilities for environmental testing.

New York Testing Laboratories—Facilities for environmental testing.

Parameters, Inc—Environmental test facilities.

Rototest—Facilities for environmental testing.

Schaevitz Engineering —Facilities for environmental testing.

Steel City—Environmental test facilities.

United Electrodynamics—Facilities for environmental testing.

United States Testing Company—Test facilities for acceleration, altitude, explosion, fungus, humidity, immersion, rain, salt spray, sand, dust, shock, temperature and vibration.

Wyle Laboratories—Liquid oxygen (LOX) cleaning facilities, including "clean rooms" that are guaranteed to deliver "certified LOX-clean" components and packages.

Wyle Research Corp.—Testing facilities for sinewave and random and complex waveform vibration testing.

Air and atmosphere cleaning and dehumidifying is an important part of environmental control.

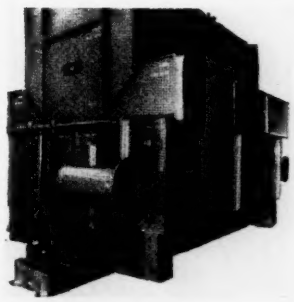
A shows Hankison "Condensifilter."

B shows air conditioning system of Niagara Blower Company.

C shows Dollinger air cleaning units.

D shows dehumidifier of Van Products Co.

A



B

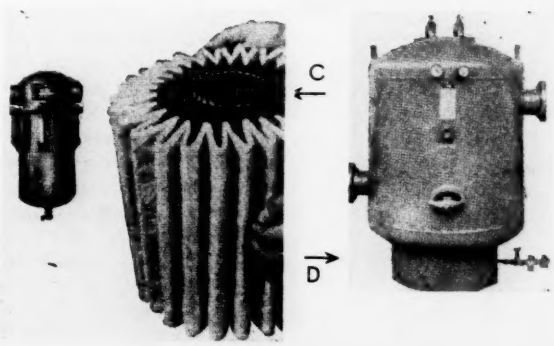


TABLE 4—AIR AND ATMOSPHERE CONTROL

Dollinger Corp.—Compressed air filters.

Hankison Corp.—Compressed-air dehumidifiers.

Johnson Corporation—Compressed air separator and aftercoolers.

Nash Engineering Co.—Clean-air compressors.

Niagara Blower Company—Atmosphere control systems for wind tunnels, high-voltage laboratories, calibration rooms, gases, and compressed air.

Surface Combustion Corp.—Atmosphere control systems.

Van Products Co.—Compressed-air dehumidifiers.

Environmental Testing Failures In Missile and Aircraft Equipment

H. J. SHAPIRO and **LEE PERMUT,** Aerotest Laboratories, Inc.

Case histories reveal the most frequent causes of electronic, hydraulic and pneumatic equipment failures during environmental testing—moisture and vibration are the principal "killers."

RELIABILITY of airborne equipment subjected to severe environmental conditions has long been recognized as a major factor to be considered in the design and manufacture of such equipment. In recent years the more severe operating conditions encountered by missiles and aircraft have added even greater emphasis until now reliability is regarded as perhaps *the* most important design factor.

This paper shows the results of two studies made recently to determine the principal types of environmental failures and their causes. The results of two of those studies are presented below and shown in Figs. 1 and 2. Study I investigated electronic and electrical equipment; Study II concerned itself with hydraulic and pneumatic equipment.

STUDY I: MILITARY AIRBORNE ELECTRONIC AND ELECTRICAL EQUIPMENT

A total of 1990 actual test reports were studied. Each report described the tests and results obtained during environmental testing of many types of electronic and electrical equipment, such as motors, amplifiers, computers, transmitters, radar sets, ignition systems, simulators, power supplies, recorders, test equipment, etc.

Not all of the 1990 cases included an environmental failure. In those cases that did, 82% of the failures occurred during the existence of three environmental conditions. The remaining 18% were attributed to a miscellaneous assortment of conditions. The three principal failure-causing conditions were:

1. Moisture (all types—humidity, salt spray, condensation).
2. Vibration and shock.
3. Extreme temperature (high or low).

Failures Due to Moisture

Moisture caused 43% of the failures. The types of moisture failures observed were:

A. Excessive moisture absorption in insulating materials resulting in deterioration or breakdown of insulation resistance or dielectric strength. *Primary cause*: Poor sealing of unit (gaskets, O-rings, etc). *Secondary cause*: Low-quality insulating material.

B. Intermittent shorts on exposed components, wiring, solder joints. *Primary cause*: Poor sealing of unit (gaskets, O-rings, etc). *Secondary cause*: Faulty internal design or assembly.

C. Excessive corrosion brought on by moisture and causing poor electrical contact in switches, relays, etc. *Primary cause*: Poor sealing of unit (gaskets, O-rings, etc.). *Secondary cause*: Use of contact materials that are not corrosion-proof.

Nearly all of the above failures could have been prevented by better sealing design. In many of the units tested no attempt at all was made to seal out moisture through the use of gaskets, O-rings, hermetic sealing, etc. Improved provisions for moisture drainage also would help.

Failure Due to Vibration or Shock

Vibration or shock caused 22% of the failures. The types of vibration-shock failures were:

A. Multiple failures (where wiring, components, brackets, etc. suffer structural failures). *Primary cause*: Absence of shockmounting or other vibration isolation, either internal or external. *Secondary cause*: Improper choice or design of shock-mounts.

B. Detail failures of internal wiring, components or mountings (usually during severe resonance). *Primary cause*: Improper choice or design of shockmounts. *Secondary cause*: Poor detail design, such as awkward location and mass of components, lack of structural support, and use of under-rated components.

Failures Due to Extreme Temperature

Extreme-temperature caused 17% of the failures. The types of temperature failures were:

A. Complete failure of one or more components. *Primary cause*: Use of under-rated components. *Secondary cause*: Lack of sufficient cooling, ventilation or heat-conducting paths.

B. Transient performance failures. *Primary cause*: Temperature instability of circuit components. *Secondary cause*: Lack of sufficient temperature insulation.

C. Binding of moving parts, such as gears and shafts. *Primary cause*: Poor mechanical design regarding tolerances and temperature coefficients. *Secondary cause*: Lack of sufficient temperature insulation.

STUDY II: MILITARY AIRBORNE HYDRAULIC AND PNEUMATIC EQUIPMENT

A total of 2600 actual test reports were studied. Types of equipment included pumps, valves, pressure switches, disconnects, flow measuring devices, actuators, cylinders, gauges, accumulators, etc.

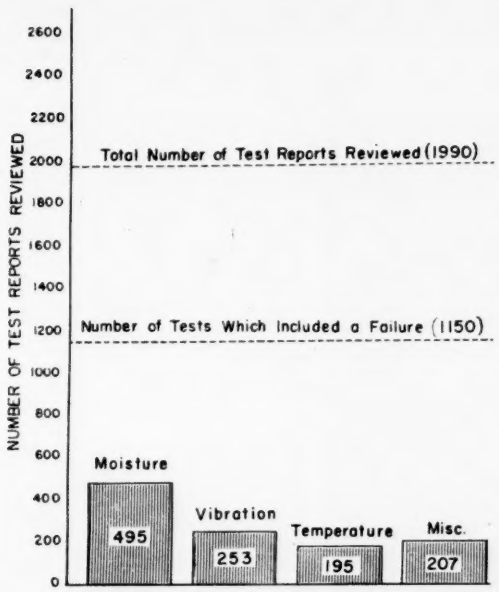


FIG. 1. ENVIRONMENTAL TEST study failures in electronic and electrical equipment.

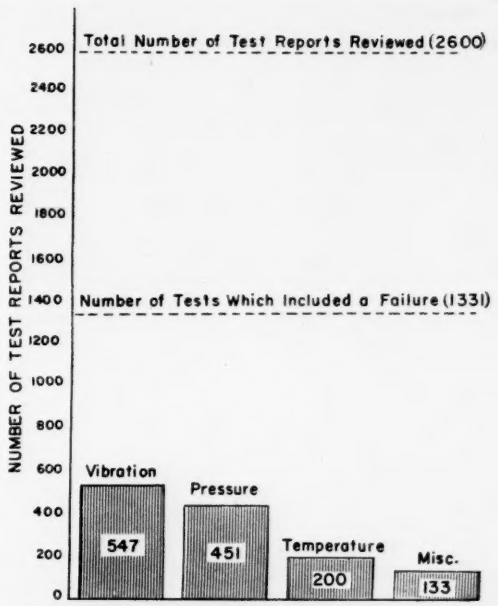


FIG. 2. ENVIRONMENTAL TEST study failures in hydraulic and pneumatic equipment.

Again, not all of the 2600 cases included an environmental failure. In those that did it was found that 90% of the failures occurred during three environmental conditions, with the remaining 10% attributed to a miscellaneous assortment of other conditions. The three principal failure-causing conditions were:

1. Vibration and shock.
2. Surge pressure and over pressure.
3. Extreme temperature (high or low).

Failures Due to Vibration and Shock

Vibration or shock caused 41% of the failures. The types of vibration-shock failures were:

A. Structural failures of housings, mounting brackets, and shafts. *Primary cause*: Improper choice of structural member materials to withstand vibration and shock. *Secondary cause*: Poor detail design; poor location and massing of components and assemblies, and lack of structural support.

B. Failures of mechanical fasteners, such as screws, bolts, nuts, and clamps working loose. *Primary cause*: Improper safety wiring, lock washers, etc., or its omission entirely. *Secondary cause*: Insufficient number or strength of fasteners for the load.

Failures Due to Pressure and Over Pressure

Surge pressure and over pressure caused 34% of the failures. The types of pressure-test failures observed were:

A. Leaks at sealing points. *Primary causes*: Improper size or type of sealing device, such as O-rings and gaskets. *Secondary cause*: Improper support of O-rings (shoulders, grooves, etc.).

B. Calibration failures of sensing elements. *Primary cause*: Sensing elements (springs, vanes, diaphragms) suffered permanent deformation during exposure to surge pressures.

C. Mechanical and structural failures. *Primary cause*: Shafts, supports, and cylinders lacking in design strength to withstand loads of extreme pressures.

Failures Due to Extreme Temperature

Extreme temperature tests caused 15% of the failures. The types of temperature failures observed were:

A. Leaks. *Primary cause*: Improper size O-rings, gaskets and other sealing. *Secondary cause*: Underrated sealing material that resulted in permanent deformation or cracking of O-rings and gaskets.

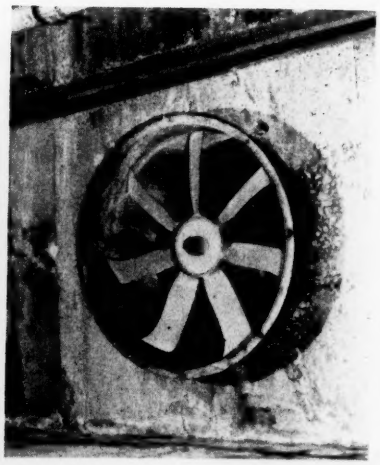
B. Mechanical binding of moving parts. *Primary cause*: Improper choice or compatibility of materials for expansion or contraction under temperature extremes. *Secondary cause*: Design-tolerance stack-up in gears, shafts.

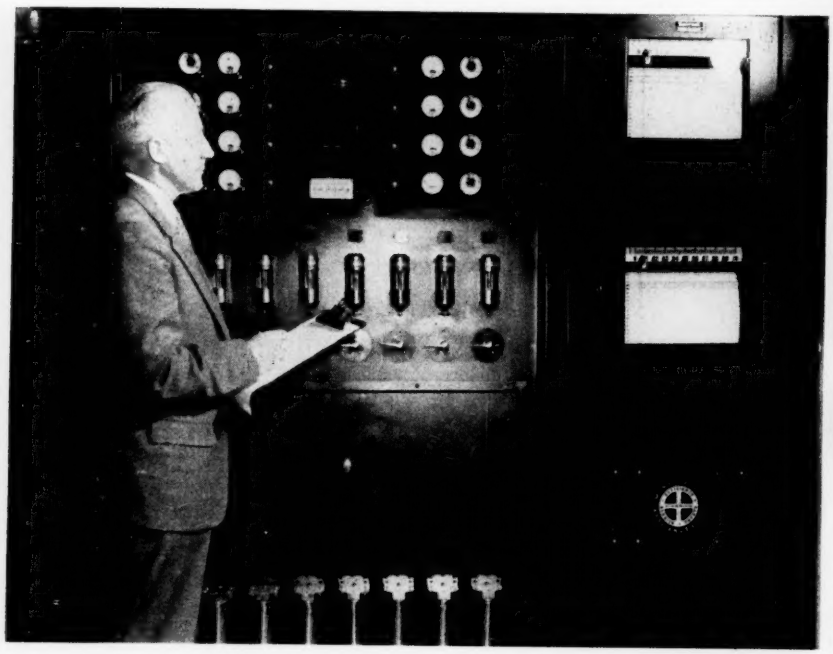
C. Pressure-drop performance failures. *Primary cause*: Poor flow-section design (failures usually occur at extreme low temperature with increased fluid viscosity).

One additional fact uncovered by these studies should cause engineers to stop and review their design carefully before releasing it for production. Of the 4,590 cases in both studies, 2,481 cases (54%) showed that the unit being tested did *not* successfully complete environmental testing during its first trip through the (Aerotest) Laboratories. Of course the great majority of those cases eventually went through, but not until varying amounts of redesign and retest were performed.

In general, the over-all results of the studies revealed two methods of improving environmental test reliability—(1) more careful selection of properly-rated components and materials and (2) more attention to early spot-testing of components and subassemblies prior to final design and assembly.

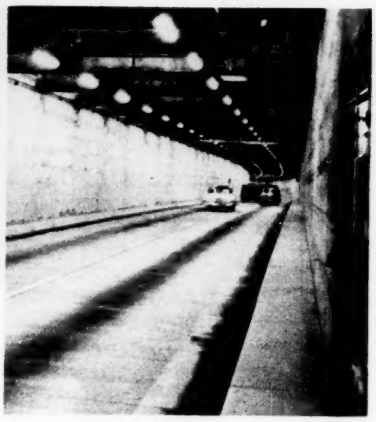
EACH ROADWAY HAS 36 individual 33" diameter, three-horsepower propeller fans delivering 15,500 cfm each





OVERLAPPING SHIFTS in the afternoon allow one operator to check equipment and perform simple maintenance operations.

THE SUBWAY, PART OF the Alaskan Way Viaduct project, provides a freeway facility under seven heavily-traveled surface streets to connect through Seattle.



Control of Subway Ventilation

H. WARD TYLER Seattle Engineering Department

TWO OPERATORS, on duty five days a week from 7:00 A.M. to 7:00 P.M., provide the only supervision needed for a 2146-foot, four-lane vehicular subway in Seattle, Washington. For the remaining twelve hours each day, and on Saturdays and Sundays, the ventilation system and other safety devices are on automatic control. After one year of operation this system has worked successfully without incident.

The Control System

Fans are automatically actuated from a central control chamber. Eight sections of nine fans each are stopped and started by carbon-monoxide analyzers developed by Mine Safety Appliances Company of Pittsburgh, Pa. Continuous air samples are taken from eight pick-up points at breathing level and carried through copper tubes to the analyzer cabinet. The air is dried and heated. It then passes to a detector cell which contains a thermopile embedded in a catalyst called "Hopcalite." In the presence of Hopcalite, CO is oxidized to CO_2 in an exothermic reaction. The thermopile generates an emf which is directly proportional to the CO content. This is indicated on a meter and also is printed on a continuous graph on recording potentiometers. As the concentration of carbon monoxide reaches 1.5 parts per 10,000 for any unit, the potentiometer closes a mercury switch and a relay operating one bank of fans.

Each pick-up point and its analyzer controls the fans in that section. If, however, the carbon monoxide content in any one section reaches 3 parts in 10,000 all four banks of fans in that roadway are automatically actuated. These fans will continue to operate for two minutes or until the carbon monoxide content drops below the critical point. In event the fans fail and the carbon monoxide content rises to 6 parts in 10,000, another mercury switch actuates a number of neon STOP MOTOR signs along the sidewall and at the same time operates a flashing red signal and a SUBWAY CLOSED sign at the entrance. At this writing these signs have never been energized as a result of high CO concentrations.

Moisture-Vapor Transmission Testing

MRS. FRANCES M. CORNEY
Atmosphere Control Co., Inc.

FIG. 1. GENERAL FOODS moisture-vapor transmission cabinet (G.F.M.V.T.), the original standard cabinet.

IN ORDER to assure the paper and film industry that all moisture-vapor transmission test figures check with each other there is a standard procedure for preparing specimens and conducting tests in one cabinet known as the General Foods Moisture-Vapor Transmission Test Cabinet or G.F.M.V.T. (Fig. 1).

The name of the cabinet arose from a test, made originally for the General Foods Corp., which has become a standard throughout the industry. The test was written into Armed Forces specifications during World War II and has been used by companies selling their products to the Armed Services ever since.

G. F. M. V. T. Procedure

A sample of the paper to be tested is first inspected for flaws, such as pin holes, creases, etc., and a good section, a circular piece, 5⅝" in diameter, is then cut out.

A 50 ml. beaker is filled with 8-mesh-screened calcium chloride and then emptied into a No. 6 standard aluminum dish. The sample paper is placed over the calcium chloride concentric with the rim. A brass template is then carefully placed over the paper, care being taken to center the template.

A wax mixture is heated in a porcelain crucible to at least 100° C. and then poured through a 20-mesh screen into the *annular space* between the brass template and the rim of the aluminum cup.

Twenty four such dishes are placed in two dessicators and remain there four hours, at which time they are weighed on an analytical balance. They are then placed in the 24-es humidity cabinet for 68 hours at 100° F and 92% R.H. They are removed from the cabinet, put into the dessicator for four hours, and weighed. This last four hours in the dessicator brings the moisture content in the paper sample to the same point it was before going into the humidity cabinet so that the difference in weight before going into the cabinet and after coming out of the cabinet indicates the amount of moisture that has passed through the sample into the dessicant.

The unit of moisture-vapor transfer is grams of moisture per 24 hours per 100 sq in of area. The difference in weight of each cup gives the grams of moisture penetrating the paper sample in 68 hours. This quantity, multiplied by 0.71, gives the transmission in grams per 24 hours per 100 sq in.

Bag (or Pouch) Method

A set of accessories, including a "Suggested Method of Procedure," is available also for the "bag" or "pouch" method of testing.

Here two sheets of the film to be tested are formed into an open pouch by sealing on three sides. Calcium chloride is then placed in a porous paper bag, weighed, and inserted into the open pouch, which is then sealed to a total inside area of 25 sq in. Each test is run with three bags made of the same specimen film.

The test bags with the calcium chloride sacks sealed inside are then placed on small racks and set inside the humidity cabinet. This allows the conditioned air of 100° F and 92% R. H. to circulate freely around all surfaces of the test bags.

At the end of 96 hours of humidity exposure, the bags are slit open and the calcium chloride sacks are weighed. The gain in weight for each sack will represent the water vapor transmission (W.V.T.) of the film in grams per 100 sq in per 24 hrs.

Maximum and minimum W.V.T. values are just as important as the average value in knowing the overall transmission rate of the sample submitted to the test. This can help determine the limits for quality control for that particular barrier material.

Some materials show an increase in W.V.T. after creasing. To determine the importance of this effect the material can be conditioned by Gelbo Flex Tester* after creasing the bags during their preparation.

*Manufactured by Package Materials Laboratories, Inc., 461 Crescent Road, Hatboro, Pa.

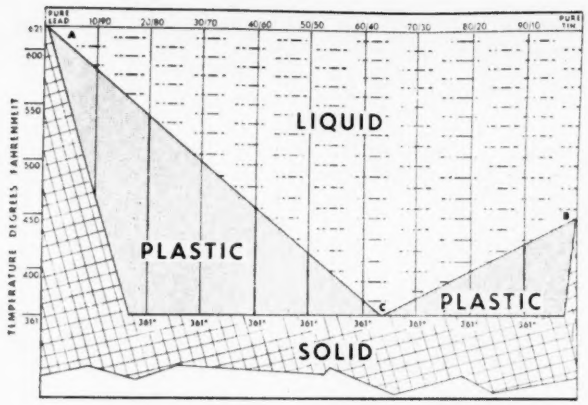


FIG. 1. TIN-LEAD fusion diagram. Point C shows eutectic mixture where there is no plastic range, but a sharp and distinct melting point—i.e., there is little or no distinguishable difference in temperature between the solid and liquid point.

SOLDERING IN THE SPACE AGE

ALVIN B. KAUFMAN
Arnoux Corporation

Increasing environmental temperature in high-mach missiles and aircraft is cause for serious review of solder termination reliability.

ENVIRONMENTAL component specifications for many systems are being up-rated from 85°C (185°F) to 125°C (257°F). Many manufacturers now have components rated at 200°C (392°F), and it appears that a MIL Specification environmental rating of 175-250°C (347-482°F) is not far off. Nuclear reactor components are being sought to withstand up to and above 315°C (609°F).

Ordinary tin-lead alloy solders become plastic or liquid at 361°F (Fig. 1) so it appears that the future use of these solders will be limited to applications other than those noted above. Spotwelding or silver soldering is not applicable for many sealing and component attachment problems; therefore, other methods must be pursued.

Further, tin-lead alloy solders are not generally suitable for the cold environments[1] of —65°F to —450°F encountered in tactical vehicle use or with liquid helium, hydrogen, nitrogen or oxygen (as in ballistic missiles). These alloy solders with a high percentage of tin are subject to deterioration if exposed to long-term use at these low temperatures.

The multitude of trade journal and handbook material on soft (tin-lead) solders fails to indicate the environmental limits of these or the higher temperature "soft solders" and there is no simple answer for an environmental temperature limit. Wire-terminal geometry, materials, vibration, and other parameters acting together establish the operational limit.

Unfortunately, environmental testing specifications were not specifically compounded for solder reliability tests. The solder or its connection receives "environmental test" only incidentally during the test of equipment. Solder procurement specifications require composition and plastic (melt point) certification only. Climatic environmental conditions are normally evaluated by test per MIL-E-5272A. This specification includes testing for items such as sand and dust, which are not applicable for solder reliability tests. Other parameters such as humidity, temperature, and salt spray are dubious in value[2].

Temperature in particular is a factor in which adequate control has not been made. Components are now rated per MIL Specification for environmental temperatures as high as 125°C (257°F), with little attention paid to the associated solder connection with which the component is held in place. Additionally, I^2R heat generated in, or radiated by, components may well bring solder connections close to the solder plastic range. Military Specification MIL-R-26B indicates that power resistors at full ratings may have surface temperatures of 200-350°C (392-662°F) in free space and still air. Coupled with this is the possibility of higher than ambient "black box" temperatures within the installation enclosure. For these reasons the use of high-temperature soft solders (Table 1) is advisable[3,4].

Certain data[1] indicate that 200-300°F is roughly the limit of soft (tin-lead) solder connections, based on solder tensile strength, and on laboratory environmental tests[5]. Although Table 1 indicates the tensile strength of some selected "high-temperature" soft solders, a generalized limit cannot be specified because of the affect of various alloys and other parameters. The tensile-strength data in itself is not enough to indicate a "safe" solder-termination temperature.

Geometric Factors

For conditions encountered in typical military applications the geometry with which containers are solder sealed or components attached to each other by solder becomes important. The part that solder plays in the attachment appears open to question. According to one reference,[6]: "The alloy attachment lies in the thin film of solder between the two metals joined together." This reference indicates that it is advisable to make a mechanical joint for strength, using the solder mainly for electrical conductivity. This fits the modus operandi commonly employed in the electronic field. Under certain high-temperature conditions this may still be correct.

TABLE I—HIGH-TEMPERATURE SOFT SOLDERS' TENSILE STRENGTH (PSI) vs TEMPERATURE

Item	Solder Material	PSI@ 80°F	°F Plastic	°F Liquid
1.	95(Tin)—5(Silver)[3]	15,000	415	430
2.	94.5(Lead)—5.5(Silver)	4,000	579	689
3.	97.5(Lead)—2.5(Silver)	3,600	580	585
4.	95(Cadmium)—5(Silver)	24,000	640	750
5.	95(Tin)—5(Antimony)[2, 3]	5,900	450	468
6.	97.5(Lead)—1½(Silver)—1(Tin)[3, 5]	3,600	580	588

Notes:

1. These are sold under various trades names and/or numbers.
2. MIL Type Sb 5.
3. A superior solder, easy flowing and wetting, will tin with activated rosin flux easily. Other corrosive fluxes are sometimes desirable for certain grades of stainless steel, dependent upon flux removal methods employed.

Shock and Vibration

However, the introduction of shock and vibration changes the picture radically. A termination in which the component lead is held to it's associated binding post by *solder alone* has proved superior[5,7] in resisting vibration, shock, and in ease of component replacement. The test parameters included the use of tin-lead solders of various alloy ratios, but did not include tests of the high-temperature soft solders listed in Table I.

A mechanical connection does not allow the solder joint to be taken to the "plastic" solder temperature under vibration because the solder fails at some point due to stress transfer or outright "throwing" of solder. Thus the solder-held termination is superior to the mechanical-solder connection in most instances.

Tensile Strength

The environmental limit must be far enough below the plastic temperature to secure a tensile strength suitable for the intended use of the solder. Where such a solder termination consists of lead wire to tube socket, or light-weight component to terminal post, etc., a tensile strength (at the elevated temperature) of about 1,100 to 2,500 psi should be adequate. Larger components or solder-sealed lids can use the same parameter if adequately held mechanically, otherwise higher psi tensile strengths may be necessary. It is important to keep in mind the possibility of higher than ambient environmental temperature at the solder connection due to heat transfer from a high-wattage resistor or other components via conduction or radiation[4]. Considerably lower environmental temperature rating should be assumed near anything but a passive or low-level power device.

Effect of Alloys

The over-all quality of a solder is governed by numerous factors[6] in addition to tensile strength vs temperature. These are flow (or wetting) of solder, chemical stability of the soldered connection, soundness and porosity of the joint, and physical resistance to shock, strain and stress.

Solder with a high percentage of tin (item 1, Table I) should not be used generally if extremely cold temperatures will be encountered for long periods, such as with equipment in a power-off condition. The tin undergoes an allotropic transformation producing a weakened alloy with resultant erratic or open conductivity. Note, however, that antimony inhibits the allotropic change in tin. The Sb5 solder (item 5, Table I) is commercially known as a "refrigeration solder." In this service the tin-antimony solder is exposed to temperatures as low as −60°F for long periods. There is no doubt that this solder will provide satisfactory solder termination bonding at −65°F. Its compatibility with liquid oxygen, or reaction to temperatures below −65°F, however, has not been completely established by the writer at this time.

The use of some other high-temperature soft solders with exotic alloy compositions is limited by their requirement for corrosive fluxes to secure sound bonding and wetting of the solder termination. Solders high in cadmium content require a flux highly corrosive to copper, and this results in rapid erosion of the soldering-iron tip. Careful post-solder flux removal or the use of the solder with other than copper (i.e., nickel, silver or other plated parts and materials) permits humidity and salt spray corrosion-resistant soldering.

High-lead low-silver-content alloy solders generally produce a poor joint, with a gray-slag cold-solder appearance. A satisfactory solder connection with the use of rosin flux is difficult. However, the addition of a small percentage of tin (see item 6, Table I) produces an excellent solder, easily used with rosin fluxes.

The solder data presented herein is the result of much trade literature research and empirical testing. Table I presents, to the authors knowledge, the majority (if not all) of commercially available high-temperature soft solders. It is hoped that the data presented will contribute important design parameters, and be a spur to greater investigation and development of solders for the high-temperature area between 361°F (tin-lead solder) and 1200°F (silver solder).

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1. Alvin B. Kaufman, "Soldering In the Missile Age," *Missiles and Rockets Magazine, March,* 1958, *pages* 201-206.

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3. *Nel Reliability Design Handbook,* OTS Report #PB121839, Office of Technical Services, Dept. of Commerce, Washington 24, D. C.

4. Harry M. Passman, "Thermal Design of Commercial Airborne Electronic Equipment," 1957 IRE National Convention Record, Part 8.

5. "Tests of Soldered Connections Without Mechanical Joints," NEL (unclassified) Report #755, March, 1957, U. S. Navy Electronics Lab., San Diego, Calif.

6. Clifford L. Barber, "Solder, Its Fundamentals and Usage," Kester Solder Company, Chicago, Ill.

7. J. Roy Smith, "Solder Is Strong Enough," *CQ Magazine,* July, 1956, pages 63, 64.

FIG. 1. THREE OF THE 15 operating stations of the Convair-Astronautics analog computing facility. The equipment sits on a plenum chamber and exhausts air into the room.

ENVIRONMENTAL PREREQUISITES FOR COMPUTER EFFICIENCY

This check list of environmental considerations for construction of a computer facility also can be of value in planning for greater efficiency and lower costs in other special-purpose rooms and departments.

R. D. HORWITZ, Convair (Astronautics) Div.

ONCE the planning for a computer facility has gone as far as selection of equipment (Fig. 1) the following outline of factors should be considered in determining the proper environment:

A. Equipment
   1. Air Conditioning
      a. Temperature control
      b. Humidity control
      c. Dust and foreign matter control
   2. Power
   3. Floor coverings
   4. Walls and partitions
   5. Lighting and colors

B. Personnel
   1. Maintenance
   2. Operators
   3. Programmers
   4. Design and construction
   5. Test stand

C. Miscellaneous
   1. Housekeeping
   2. Storage
   3. Safety precautions

We can examine these requirements individually.

Air Conditioning

An air distribution system that brings cold air in at floor level is shown in Fig. 2. The rack blowers suck in the air and exhaust it at the top. The room air is recirculated via a separate conditioning unit. Drawbacks to this method are inefficient air control and personnel discomfort. The same applies to the variation shown in Fig. 3, which is the least desirable of those shown.

Fig. 4 shows cold air being fed to the equipment via a floor plenum. The air enters the rack under pressure from the bottom through a hole in the plenum. The quantity of air is adjusted by means of louvers in the hole. Air is then exhausted to the room.

Fig. 5 shows a closed-circuit system with cold air entering the equipment at the base and being exhausted into overhead ducts to be re-circulated. Of these four concepts Fig. 5 shows the most efficient; but it is the most costly and the least flexible. Fig. 4 illustrates a good compromise.

Temperature

Temperature is the worst enemy of reliability. The optimum temperature for equipment and personnel is about 75 F. Therefore the refrigeration unit of

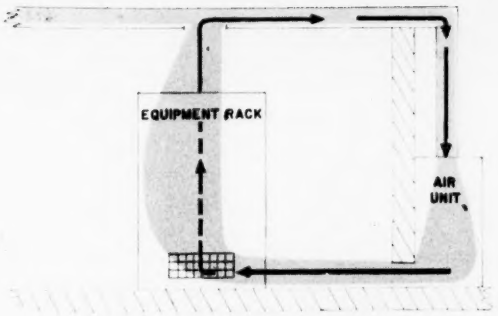
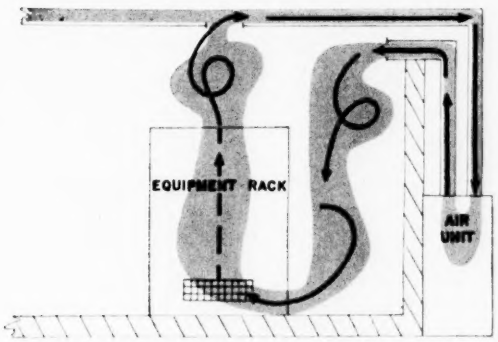


FIG. 2. COMPUTER EQUIPMENT can simply use room air for cooling.

FIG. 3. COOLING EQUIPMENT with room air that is drawn in and exhausted at or near the ceiling creates drafts.



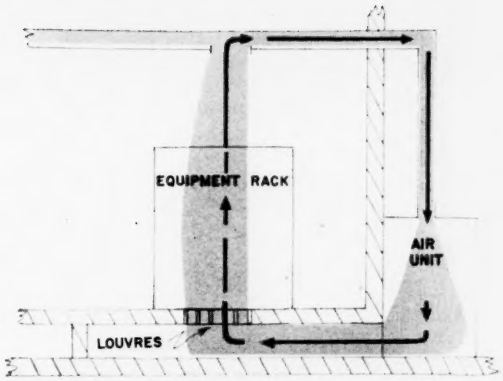
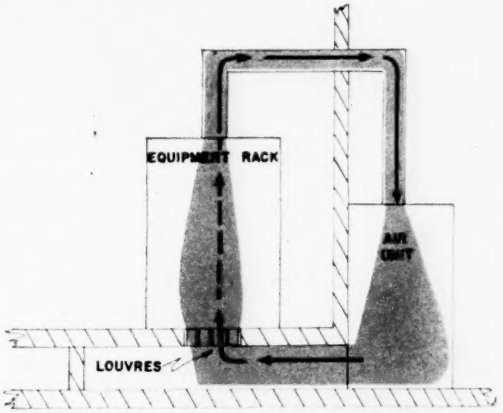


FIG. 4. AIR SUPPLY PLENUM under the floor is best way to feed cooling air to equipment.

FIG. 5. SEPARATE, CLOSED, air cooling system provides ultimate control of air.



the air conditioning system should be able to maintain the air exhaust at this temperature. This will normally require an air entrance temperature of approximately 55° F.

A well-designed system should be able to maintain the temperature within a range of ±2F° regardless of the total heat being dissipated. This tolerance also should be based on a 100% duty cycle, i.e., the equipment dissipating heat 24 hours a day, 7 days a week, as properly designed electronic equipment is most reliable when it is left operating continually.

Humidity

Factors important to consider here are leakage, static electricity, oxidation and personnel comfort. If the facility contains magnetic tape units, paper tape, paper recorders, etc., a medium amount of moisture can cause sweating, leakage in high-impedance circuits, and corrosion of moisture-sensitive elements. A range between 40% to 60% R. H. is satisfactory.

Dust and Foreign Matter

Dust control for computer facilities is better evaluated by an industrial psychologist. Some places where dust control is paramount require electrostatic precipitation, nylon clothes, and head coverings. Usually adequate dust control is accomplished by filtration. Plastic elements build up a charge by passing air through the filter thus precipitating most of the very fine particles; the larger particles are stopped mechanically. Soft pile synthetic door mats at all entrances to the facility will remove most of the dust from footwear. Positive pressure in the equipment area will keep dirt from blowing in.

Whether or not smoking is harmful to equipment has been a point of argument. Until it is definitely proved that smoke itself is not harmful, smoking should be forbidden. Ashes are definitely harmful.

Power

It would definitely be advisable to have a separate substation supplying power for the computer facility. Such a station would eliminate line transients that can cause so many computational errors. In addition, servo-controlled autotransformers which keep the line voltage within ±1% of nominal voltage are desirable. Lighting is the only kind of load other than the actual equipment that should be permitted on the secondary of this substation.

There is value in having a motor generator set rather than a conventional power source. It is also more expensive initially and more difficult to maintain.

Floor

Do not try to reduce the peripheral costs such as for proper floor covering. Dust control is costly. Wax and cleaning compounds give off harmful fumes and cause dirt to adhere to equipment. Vinyl or rubber floor coverings seem to be the answer. These are flexible, have high electrical resistance, wear well, require no waxing and look appealing. Rugs add a note of plushness but accumulate dirt and generate lint.

Walls and Partitions

The major equipment area should be isolated from other than operating personnel. Adequate visual communications can be maintained through windows, and sound via intercoms. Particularly noisy pieces of equipment can be sound controlled by means of partitions. The walls and ceilings should have soundproofing, but must be constructed of dust-free material.

Lighting and Colors

Flush ceiling fixtures are attractive and provide good lighting where close work is required, such as on patch boards. They should provide at least 100 foot candles at desk height. Equipment having visual displays will require less intensity. The light fixtures should be easy to clean and service.

In the past, electronic equipment manufacturers have been almost prosaic in their choice of finish colors. In 20 years we have progressed from black bakelite to black crackle to grey crackle to television blue. Only recently have manufacturers started using functional colors. This also applies to surrounding surface areas. Equipment areas are not antiseptic; let's liven them up with pastels and interesting color variations!

Maintenance Personnel

Maintenance procedures have one thing in common —keeping the equipment functioning as reliably as possible. Normally the environment required for equipment maintenance is as stringent as that for the operating area as here components are most exposed to the ambient air.

Other necessities for such an area are adequate regulated-power outlets, a sink with hot and cold running water and accessible storage for parts and test equipment. Actual construction work should be physically separated from maintenance areas because of the dirt made in building. How many relays have become unreliable because of a piece of iron filing adhering to the pole piece?

Operators

Separate areas should be provided for "thinking" and "doing." The "thinking" areas should be located adjacent to the equipment, but separated physically. Room for permanent personnel is required plus a separated space for transients or customers for consultation activities that will not disturb others nearby. The "doing" area should be with the equipment. A minimum of desk space should be provided so that operators will have a place for papers, books, etc., but not enough space so that it will be too inviting for a prolonged stay in the equipment area.

Programmers

A programmer is a rare and precious creature; he should be provided a quiet, studious, academic atmosphere. His is a tedious job that requires concentration. Soundproofing and comfort air conditioning are incentives for keeping programmers.

Design and Construction

Most facilities grow and require an area for design and fabrication of new electronic and mechanical equipment.

Test Stand

In analog simulation, hardware is often tied in to the computer. Visual communication in addition to electrical connections are required. The closer such test equipment is to the computer, the better the simulation because long cables cause signal deterioration.

Housekeeping

Housekeeping and engineers seem to be congenital strangers but a fine-looking facility provides a strong incentive to keep the place neat. Dust filtration, door mats and plastic tile have been mentioned earlier as means of alleviating dirt accumulation. Another desirable device is a vacuum cleaning system with sufficient suction to really remove dirt. The system should exhaust to the outside. Exhausting inside is just rearranging the dirt and only causes more trouble.

All filters in the equipment and air conditioning system should be on a routine replacement-cleaning schedule. Cooling efficiency drops drastically as the filters clog.

Storage

Storage space is usually considered non-productive space and receives poor consideration in planning. Such space is required for cards, tapes, parts, wire, spare units, paper, etc. Stacking against the wall is one way of solving the problem but nullifies the housekeeping, accessibility, appearance and efficiency of an area that we have stressed. Storage need not be fancy, but should be adequate.

Safety Precautions

Insurance companies usually insist on water sprinklers for fire protection. However, in an area filled primarily with electronic equipment, water would aggravate an electrical fire. Numbers of CO_2 bottles should be available plus an alarm system that will shut off the power if room or equipment temperatures reaches a certain value. Care must be taken in designing a power shut-off system because certain types of equipment have special cooling.

Strategic points should be designed for power shut-off switches so that all power can be eliminated quickly in case of emergency or obviously dangerous situations.

Adequate waste disposal units should be supplied to reduce fire hazards due to accumulations of paper and flammable material.

In summation:

(1) Plan carefully.
(2) Take the advice of the equipment manufacturer.
(3) Plan for the future.

FIG. 1. FINAL ASSEMBLY and testing of superior quality relays is performed in the "Super White Room." Positive pressure of 0.06" to 0.08" W.C. keeps outside air from entering through airlock.

FIG. 2. OPERATOR ADJUSTING a micro-miniature relay. Test enclosure has a glass top to doubly protect the relay from extraneous matter.

Super White Room

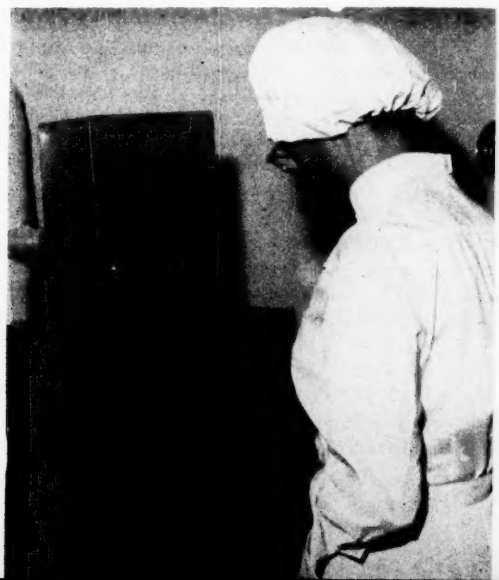
CHRIS EIRICH
General Electric Co.

SPECIALIZED APPLICATIONS of hermetically sealed relays require a manufacturing process that is surgically clean. To manufacture within exacting conditions, the Specialty Control Department of General Electric has constructed a totally enclosed room with a controlled atmosphere in which extraordinary precautions are taken to eliminate dust and dirt (Fig. 1).

The temperature in this room is kept to 72°F (± 3°) and the humidity controlled to 35% (±5%). Special air filtering equipment takes prefiltered air through an electrostatic precipitator before it enters the room.

The room is 26′ x 22′; a vestibule, dressing room and 4′ x 4′ electrically controlled air lock are attached.

FIG. 3. INTERNAL ASSEMBLY of relay is subjected to special cleaning to remove any foreign matter which may have been accumulated during assembly operation.



The room is of double-wall construction with air space and insulation between two sheet-metal sides and ceiling. The floor covering is of special vinyl sheet to eliminate the usual dust accumulating cracks of regular tile floors. All joints are sealed air tight. The floor and ceiling are coved and all corners in the room are rounded. Lights are mounted flush with the ceiling. Two large double-glass picture windows were built with the inside glass panes flush with the wall. Power switches are recessed into the wall. All these precautions are to avoid dust catching.

All material used in the white room is pre-cleaned and placed in special covered containers and trays. A material pass-through compartment to the vestibule and the personnel airlock are electrically controlled to allow opening one door only if the opposing door is closed. A two-way speaker system keeps traffic in and out of the room to a minimum. Names of people authorized to enter the room are posted outside, all others must have special permission to enter. Two nylon uniforms, caps and special shoes are furnished each operator. None of this special clothing can be taken outside the vestibule except for cleaning.

The entire white room, vestibule, dressing room and airlock are vacuum cleaned every noon and washed every night. Vacuum hose is connected to several vacuum outlets built into the walls and capped.

Air samples are taken with an electrostatic dust sampler at a controlled rate of 3 cu ft per minute. The dust collected in the sampler tube is then washed in a measured amount of double distilled water. A smear of this liquid is then placed in a Dun cell and dust particles counted under a special microscope. Dust counts taken with this method in the average home or room show well over one million particles per cubic foot, ranging to one hundred million in some uncontrolled factory areas. Goal for the white room is less than 2,500 dust particles per cubic foot with the maximum particle size under six microns.

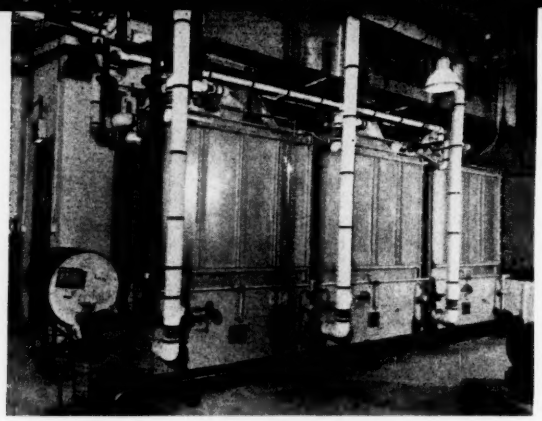


FIG. 1. LONGER COMPUTER TUBE life is one of the benefits of this humidity control system at Massachusetts Institute of Technology's Lincoln Laboratory. (Photo courtesy Niagara Blower Co.)

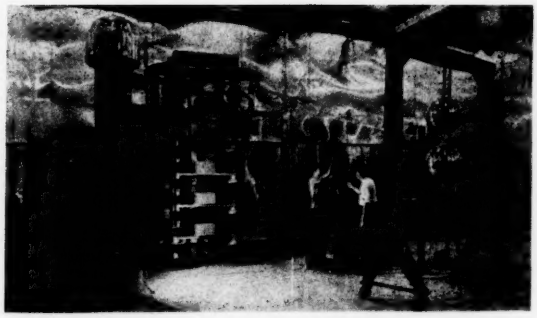


FIG. 2. STUDY OF ATMOSPHERIC static electricity requires accurate humidity control at General Electric's High Voltage Laboratory. (Photo courtesy Niagara Blower Co.)

Applications Of

AS TOLERANCES become more critical and instruments become more sensitive, the need for controlled environmental conditions increases. These reports show how chemical-type humidity control is being applied in a computer room at Lincoln Laboratory, MIT, in high-voltage engineering at the General Electric Company, in wind-tunnel work at Pratt & Whitney, in instrument calibration at Tinker Air Force Base, and in precision coating processes at Simpson Optical Manufacturing Company.

PRESSURIZED ATMOSPHERE AT LINCOLN LABORATORIES

HUMIDITY control equipment at Lincoln Laboratories, Lexington, Mass., dehumidifies outdoor air brought into the building in large quantities to pressurize the interior atmosphere and maintain a low dew-point temperature. Electron tube life is extended at this constant, low, dew point. This atmosphere-generating equipment (Fig. 1) is installed in duplicate, enabling switching over to alternate facilities in event of mechanical failure within either system. Repair work can then proceed without interruption of service.

This control humidity system has a capacity to treat 8500 cfm of outside air entering at a maximum condition with 95° dry-bulb temperature and 78° wet-bulb temperature to a leaving condition of 63.5° dry-bulb temperature and 31° dew-point, when supplied with 140 gpm of water entering at 42° and 1230 pounds per hour of steam at 50 psig.

STATIC ELECTRICITY AT HIGH-VOLTAGE LAB

HUMIDITY control in the General Electric High-Voltage Laboratories, Pittsfield, Mass., was necessary to study lightning bolts and static electricity in the atmosphere, and the behavior of electric insulation under different combinations of temperature and relative humidities. The air moisture in the lab (Fig. 2) is controlled by the air-to-liquid contact method using water or "No-Frost" solution as the contact liquid. This accomplishes the task of adjusting to any temperature or humidity over a wide range.

VERY DRY AIR FOR SUPERSONIC WIND TUNNEL

THE supersonic wind tunnel (Fig. 3) for United Aircraft Corporation's Research Labs. at East Hartford, Conn., must be operated with very dry air to prevent condensation shock, which distorts the airflow pattern. A solid dessicant dryer must be used in final drying to reduce moisture content to a negligible level. A liquid absorbent conditioner serves as a primary dehumidifier, removing about 80% of the moisture contained in outdoor summer air. The liquid absorbent can handle heavy moisture loads without producing high dryness, whereas solid desiccants have the opposite characteristic. The combination of the two produces highly desirable results.

GAGE CALIBRATION AT TINKER AIR FORCE BASE

AT THE Oklahoma City Air Material Area Headquarters, Tinker Air Force Base, as at similar facilities over the nation, gages are periodically checked against prime masters (which are calibrated at the MAC headquarters at Wright-Patterson Air Force Base, Dayton, Ohio, or at the National Bureau of Standards in Washington). The checked and corrected gages then are returned to serve as masters in their areas. The Oklahoma City Air Material headquarters administers a 13-state area in the southwest.

A simple air-conditioning system, using a Kathabar

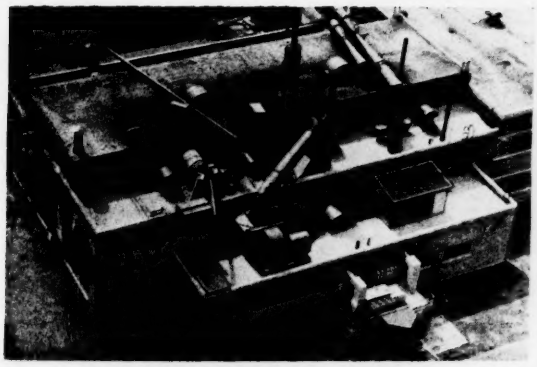


FIG. 3. UNITED AIRCRAFT Corporation's supersonic wind tunnel requires low-moisture-content air to prevent "condensation shock" which distorts the airflow pattern. (Photo courtesy Niagara Blower Co.)

FIG. 4. MASTER GAGE ROOM. Extended use of close tolerance devices in weapon systems makes air conditioning imperative. (Photo courtesy Surface Combustion Corp.)

Humidity Control

chemical-type humidity conditioner was installed in a master gage room to maintain the best environment for the instruments (Fig. 4). All standards, such as master gage blocks are calibrated at 68°F, ±1°F, and relative humidity is controlled at 45 to 50% to prevent rust and corrosion on machined surfaces of the measuring devices, and to keep the air in the master gage room clear of dust.

This type humidity conditioner uses a solution (essentially lithium chloride) to absorb the moisture from the air.

The Kathabar unit consists basically of an air washer section and a regenerator section. Both the dehumidifying and the regeneration phases are continuous and automatic; 350 cfm of outside air at maximum design conditions of 100° dry bulb and 130 gr/lb moisture content passes into the Kathabar unit after being mixed with 1,000 cfm of recirculated air from the gage room. The mixture has a maximum temperature of 76.3°F and moisture content of 67 gr/lb. Chilled water at 54°F is used as coolant for the Kathene solution; 87 lb/hr of moisture are removed by the unit. The conditioned air is mixed with recirculated air and then passes through a cell-type electronic precipitator to maintain a dust factor of 5% maximum.

After-cooling and after-heating units condition the air further for final delivery to the master gage room.

MILLIMICRON TOLERANCES IN LENS COATINGS AT SIMPSON OPTICAL MANUFACTURING CO.

ONE of the most important processes in optical manufacture is lens coating, plus related work such as aluminizing and mirrorizing.

Precision lenses are coated to cut down the surface reflection of glass and to improve transmission of light. The coatings consist of incredibly thin films of metals or salts, deposited to a precise thickness on the surface. Specific coatings must be one quarter of the wave length of light to permit light to be transmitted through the lenses: For instance, for green light the coating is one quarter of 550 millimicrons (a millimicron is 10^{-6} millimeter).

The vacuum evaporating process can be used to make films on glass for surface reflection modification or for electrical properties. The films can be evaporated through masks to form reticle patterns and graduations. They can be deposited on metals for decorative purposes, and they can be applied so that metal parts can be effectively soldered to glass parts.

At Simpson, the vacuum required for acceptable lens coating with magnesium fluoride is 5×5^{-5} millimeters of mercury. This is produced by vacuum pumps operating in a dry atmosphere. Normal air moisture would condense in the pumps and they would be unable to create and maintain the high vacuum needed. The conditions to be maintained in the lens coating room for best results are 85°F, 15% relative humidity.

Originally the company depended on dehumidifications through conventional refrigeration equipment. This, however, called for either a shutdown of the particular operation during defrosting cycles or installation of standby equipment.

Three years ago a Kathabar chemical-type humidity conditioner was installed to maintain these conditions. The system calls for mixing 300 cfm of outside air at maximum conditions of 95°F, 120 gr/lb moisture content, with 2200 cfm of recirculated air at 85°F, 27 gr/lb. This is passed through filters and enters the Kathabar low-temperature package unit at 86°F, 38 gr/lb. The unit delivers the air at 54°F, 23 gr/lb to an afterheating coil which raises it to the required 82°F. The internal sensible load is calculated at 8400 Btu/hr, and the internal latent load at 6200 Btu/hr.

MILITARY STANDARD TEST

These excerpts from "Military Standard Test Methods for Electronic and Electrical Component Parts" (MIL-STD-202A, 24 October 1956) describe the purpose for each of the environmental tests used by the Army Signal Corps, Navy Bureau of Ships, and Air Force.

A NUMERICAL INDEX of the test methods used by the Army Signal Corps, Navy Bureau of Ships and Air Force for electrical and electronic components is given in Table 1.

TABLE 1—NUMERICAL INDEX of TEST METHOD

Method No.	Date	Title
		Environmental tests (100 class)
101A	24 Oct 1956	Salt spray (corrosion)
102A	24 Oct 1956	Temperature cycling
103A	24 Oct 1956	Humidity (steady state)
104A	24 Oct 1956	Immersion
105A	24 Oct 1956	Barometric pressure
106A	31 May 1957	Moisture resistance
107	24 Oct 1956	Thermal shock
		Physical-characteristics tests (200 class)
201A	24 Oct 1956	Vibration
202A	24 Oct 1956	Shock (specimens weighing not more than 4 pounds).
203	24 Oct 1956	Random drop
204	24 Oct 1956	Vibration, high frequency
		Electrical-characteristics tests (300 class)
301	6 Feb 1956	Dielectric withstanding voltage.
302	6 Feb 1956	Insulation resistance
303	6 Feb 1956	DC resistance
304	24 Oct 1956	Resistance temperature characteristic
305	24 Oct 1956	Capacitance
306	24 Oct 1956	Quality factor (Q)
307	24 Oct 1956	Contact resistance

Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.

Copies of this standard may be obtained for other than official use by individuals, firms, and contractors from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Both the title and identifying symbol number should be stipulated when requesting copies of military standards.*

Salt Spray (Corrosion). The salt-spray test has received its widest acceptance as a test for evaluating the uniformity (thickness and degree of porosity) of protective coatings, metallic and non-metallic . . . The salt-spray test is especially helpful as a screening test for revealing particularly inferior coatings.

Temperature Cycling. This test is conducted for the purpose of determining the resistance of a part to the shock of repeated surface exposures to extremes of high and low temperatures for comparatively short periods of time, such as would be experienced when equipment or parts are transferred to and from heated shelters in arctic areas.

Humidity (Steady State). This is an accelerated environmental test, accomplished by the continuous exposure of the specimen to high relative humidity at an elevated temperature. This method, while not necessarily intended as a simulated tropical test, is

**When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligations whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may be related thereto.

METHODS FOR COMPONENTS

of use in determining moisture absorption of insulating materials.

Immersion. This test is performed to determine the effectiveness of the seal of component parts, such as detecting a defective terminal assembly, or a partially closed seam or molded enclosure.

Barometric Pressure. This test is intended primarily to determine the ability of component parts and materials to avoid dielectric-withstanding voltage failures due to the lowered insulating strength of air and other insulating materials at reduced pressures . . . Other effects of reduced pressure include changes in dielectric constants of materials, reduced mechanical loading on vibrating elements, such as crystals, and decreased ability of thinner air to transfer heat away from heat-producing components.

Moisture Resistance. The purpose is evaluating, in an accelerated manner, the resistance of component parts and constituent materials to the deteriorative effects of the high-humidity and heat conditions typical of tropical environments.

Thermal Shock. This test is conducted for the purpose of determining the resistance of a part to exposures at extremes of high and low temperatures, and to the shock of alternate exposures to these extremes, such as would be experienced when equipment or parts are transferred to and from heated shelters in arctic areas.

Vibration. The vibration test is used to determine the effects on component parts of vibration within the predominant frequency ranges and magnitudes that may be encountered during field service.

Shock (Specimens weighing not more than 4 pounds). The shock test is intended to determine the suitability of small parts, with or without auxiliary protection, for use in electronic equipment which may be subjected to moderately severe shocks as a result of suddenly applied forces or abrupt changes in motion produced by rough handling, transportation, or field operation.

Random Drop. The random-drop test is used to determine the effects on component parts of random, repeated impact due to handling, shipping, and other field service conditions. The test is an accelerated test designed to indicate structural and mechanical weaknesses of types not necessarily detected in shock and vibration tests.

Vibration, High Frequency. The high-frequency vibration test is performed for the purpose of determining the effects on component parts of vibration in the frequency ranges of 10 to 500 cps or 10 to 2,000 cps, as may be encountered in aircraft, missiles, and tanks.

Dielectric Withstanding Voltage. This is used to prove that the component part can operate safely at its rated voltage and withstand momentary overpotentials due to switching, surges, and other similar phenomena.

Insulation Resistance. This test is to measure the resistance offered by the insulating members of a component part to an impressed direct voltage tending to produce a leakage of current through or on the surface of these members.

D-C Resistance. This test is to measure the direct-current resistance of resistors, electromagnetic windings of components, and conductors. It is not intended that this test apply to the measurement of contact resistance.

Resistance-Temperature Characteristic. It is the purpose of this test to determine the percentage change in direct-current ohmic resistance from the d-c ohmic resistance at the reference temperature, per unit temperature difference between the test temperature and the reference temperature.

Capacitance. The purpose of the test is to measure the capacitance of component parts. Preferred test frequencies for this measurement are 60 cps, 120 cps, 1 kc, 100 kc, and 1 mc.

Quality Factor. The purpose of the test is to measure the quality factor, commonly called Q, of electronic parts such as capacitors and inductors.

Contact Resistance. The purpose of the contact-resistance test is to determine the resistance offered to a flow of current during its passage between the electrical contacting surfaces of connecting components, such as plugs, jacks, connectors, and sockets, or between the electrical contacts of current-controlling components, such as switches, relays, and circuit breakers.

Viscosity As A Process Variable

R. A. MINARD

Brookfield Engineering Laboratories, Inc.

Viscosity control can provide practical gains to the user of fluids by controlling this primary variable directly.

FUNDAMENTAL characteristic influencing the ease and effectiveness with which most industrial liquids flow is its viscosity—its flow properties. If it is too viscous it will not spray well, if it is too "thin" it may have poor dipping characteristics, etc.

Viscosity Determinants

What will make our fluids different today from what they were yesterday, or from what they will be in five minutes? Here's a list:

1. Changes in concentration or % solids. A small error here can be chaotic.
2. Changes in the character of incoming ingredients, particularly if "natural" products are encountered. One bag of starch can differ from its neighbor of the same manufacture and grade by 200%; the viscosity of heavy cream depends on the breed of the cow, its state of mind, and the grass it ate—among other things.
3. Temperature changes will affect viscosity.
4. Plant cleanliness—what was in the tank when it was supposed to be empty?
5. Losses in the liquid system during storage or processing due to evaporation, preferential absorption, or freezing.
6. Changes in processing equipment (such as wear in a nozzle, changes in mixing speed, or erosion of a valve) can contribute to a fluid's misery.

Control the Prime Variable

In many cases cause and effect are apt to become clouded. Chocolate must be kept in an enrober between certain temperature limits to retain its original character as a food; and it is controlled to an extremely close temperature to maintain good coating characteristics. One is tempted to ask "Why not measure coating characteristics directly and control them by adjusting the temperature within preset limits?"

The specific gravity of glue will change with the % solids added, as will the viscosity. The control of liquid density is in many cases regarded as the prime factor affecting its use on a coating machine. While % solids can determine the strength of the adhesive, it will not insure a uniform coating thickness or, more generally, its flow properties.

Starch is often cooked with the aid of rather elaborate time-and-temperature controls to bring it to the right "operating" viscosity. This has been going on for so long that these indirect controls are regarded as direct, and the suggestion that their effectiveness is limited is heresy.

In many cases a long look will show that the controlled variables are not the fundamental ones. While a material's ability to flow, coat, cover or spread may be related to solids, temperature, or bovine breed, *the relationship is secondary*. Viscosity is the determining factor.

Newtonian Viscosity

Newton defined viscosity in terms of a liquid bounded by two parallel planes (of area A), separated by a distance X. If the planes move at a velocity differential v, Newton said that the force, F, required to maintain this difference in speed was proportional to the velocity gradient through the material (dv/dx) and to the viscosity of the material η:

$$F/A = \eta\, dv/dx$$

$$\eta = (F/A)/(dv/dx) = F'/S$$

$$= \frac{\text{shear stress/unit area}}{\text{rate of shear}}$$

A material requiring a shear stress of one *dyne per square centimeter* to produce a rate of shear of one *inverse second* has a viscosity of one *poise* (100 centipoises).

This means that for a given applied stress a material of high viscosity flows slowly; one of low viscosity moves quickly. Implied in this definition is the linear dependence of stress with movement—i.e., if you apply twice the force a liquid will move twice as fast, and the ratio between stress and rate (viscosity) should remain the same.

If only it were as easy as that! Take a bottle of catsup: tip it upside down. Chances are that it will flow slowly from the bottle. Now move the bottle rapidly back and forth. The catsup will flow faster from the bottle; its viscosity seems lower! We have here a *non*-Newtonian viscosity—that is, a non-linear relationship between stress and rate. Increasing the rate of movement of the bottle actually "thinned out" the material to the point where it flowed freely.

The opposite relationship also can be demonstrated in the kitchen. A suspension of corn starch in water can be made to pour in a fashion similar to heavy cream. The same liquid will become solid and shatter when struck with a hammer.

Such non-Newtonians comprise about 85% of the materials encountered in industry.

Controlling Nonlinear Viscosity

An instrument used to measure viscosity senses resistance to fluid movement. Sensing may involve a direct measure of force, time, damping, displacement, or pressure drop; all of which are related to fluid resistance. With non-Newtonians it is extremely important that this movement always be at the same *rate*, so that the resulting resistance can be fixed to some reference point. For instance, catsup can vary from 12,000 to 300 centipoises over a 10:1 change in applied movement.

Another effect that is fairly common is *thixotropy*. A material's resistance to flow may depend not only on the rate of induced movement but also on the duration of that movement and any previous agitation that it may have experienced. (The longer you stir it, the thinner it gets.) Resistance to flow must be sensed at a point in the process where pumping rates and agitation history both are constant. Any change in these variables will cause a change in the fluid's resistance to flow without any fundamental change in the material's composition. All materials of this character should be agitated thoroughly as they are being used if uniform operating properties are to be expected.

Temperature variation also can cause changes in viscosity that do not reflect fundamental differences. However, in many cases temperature already is controlled; or the changes that occur through other factors, such as solvent loss, are so great as to mask the effects of minor variations in fluid temperature. High % solids suspensions and slurries do not show much change in any event.

Where temperature must be taken into account (as in analytical polymerization, oil blending etc.) the relationship between viscosity and temperature is exponential. Most process viscometers have temperature compensation.

A recording of process viscosity is generally an eye opener. The unsuspected variations and their magnitude is enough to make most production people shudder.

Viscometers can control viscosity within 1%, although most processes require control only to 5%. However, variations without viscosity control can run to 200%! The accuracy requirements make on-off type control adequate for most processes.

Applications in Manufacture of Electronic Components

A manufacturer of electronic components (resistors, printed circuits, etc.) required that they be covered with a tough plastic for electrical and mechanical reasons. A three-stage dipping operation covered the components with a thermosetting resin powder suspended in acetone. After dipping, the covered components were baked to form a tough outer coating. The viscosity at each stage had to be maintained at predetermined values to obtain uniform appearance, strength, performance, weight, and thickness.

The dipping machines caused enough solvent loss to change the viscosity at the rate of 3%/minute. This rate also depended on the humidity within the room and the size and number of pieces being treated.

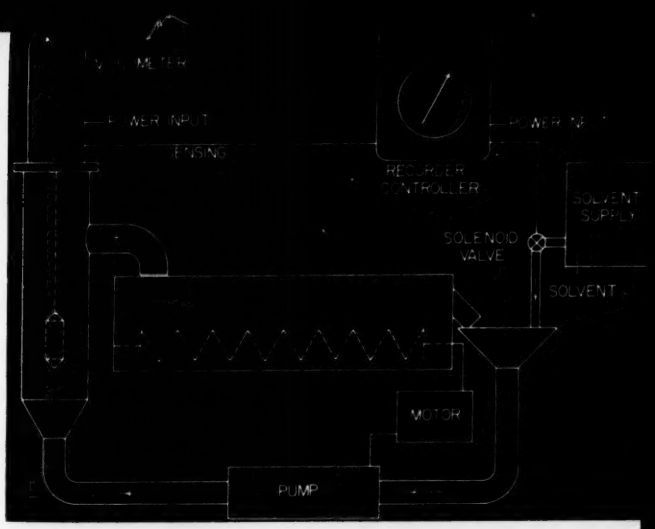


FIG. 1. DIPPING STATION shows viscometer (left) introduced into tank input stream and used to control addition of solvent (right) to maintain required viscosity.

Examination with a multi-speed rotational viscometer showed that the slurry was non-Newtonian, apt to settle out, and had some residual thixotropy in that it thickens on standing, even if solvent loss is prevented. In the laboratory it was difficult to ascertain the relationship between resistance to flow and solvent concentration because by the time small amounts were mixed in thoroughly, evaporation dissipated an unknown amount, sometimes in excess of that added.

It was recommended that a process-mounted rotational viscometer be installed directly on each dipping station to control viscosity through the on-off addition of acetone because:

1. Viscosity, not solvent concentration, was the prime variable.
2. Measurement at constant shear was a necessity for this shear-sensitive slurry.
3. A continuously acting instrument was needed where such rapid changes occurred.
4. The rotational principle previously had been judged most satisfactory for solid-bearing systems.

The design of the dipping stations and the requirements of the control situation happily coincide in that each station had a large circulating system (Fig. 1) containing a constant-speed Moyno pump. By putting the viscometer in the system as shown it was possible to:

1. Measure the material under constant shearing conditions and with a uniform agitation history. (If the pump had been a variable-speed centrifugal unit, for example, the actual viscosity of this thixotropic slurry would have varied with its speed).
2. Introduce solvent at a point where it would become thoroughly mixed into the slurry.
3. Measure a representative sample (the lines were sized so that the contents of the tank were thoroughly turned over in less than a minute).

Through this rather simple control—despite the complexities of the process liquid—the manufacturer was able to insure uniform coating thickness, weight, appearance, strength and performance.

Journal of the S C M A . . .

SOUTHERN CALIFORNIA METER ASSOCIATION

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Metering Problems in The Navy Calibration Program

This Naval Bureau of Ordnance Calibration Program assures accurate calibration of test instruments for industrial contractors, and efficient use of standards laboratory facilities.

L. M. MORROW
Aero Science Co.

INCREASING accuracy requirements for ordnance equipment increases the problem of incompatibility of test instruments. This problem of incompatibility has been the basic subject of untold conferences between contractor and user or between subcontractor and prime contractor or sometimes even between the organizational divisions of one contractor. The Naval Bureau of Ordnance Calibration Program was instituted to relieve this situation and also to assure the compatibility of test instruments throughout the plants of the contractors involved. This program, as it is now operating, provides the following assurances:

1. The compatibility of test instruments is assured by designating which instruments are to be used as a standard of measurement in any given area by the Measurement Standards Division of the Naval Inspector of Ordnance, Pomona, California.

2. The compatibility of calibration measurements is assured through the continual writing of special calibration procedures. These procedures are written not only for use of the standard instrument by which the test equipment is calibrated, but for the entire system used in the calibration of this test equipment.

3. The proper calibration of each standard is assured through the use of information fed back to the Measurement Standards Division from the laboratories participating in the program. A complete life history is kept of each instrument.

4. The maintained accuracy of the test instrument is assured.

Participation

Naval Bureau of Ordnance establishments, Bureau of Ordnance contractors and sub-contractors, and (based on special priorities) Department of Defense contractors all are eligible to participate in this program. The requirements for such participation are that the contractor and sub-contractor are holders of Bureau of Ordnance contracts and that the cognizant government agency inspector certifies the need for calibration.

The BuOrd Calibration Program is constructed to carry calibration services from the National Bureau of Standards to the ultimate user of test equipment with the utmost efficiency and a minimum of down time for the standard involved.

Primary Standards Laboratories

The *Bureau of Ordnance primary standards laboratory* is the highest accuracy echelon of the struc-

AUGUST MEETING: Thursday, the 21st, Rio Hondo Country Club, Downey, Calif.

FEATURE: Mr. Neil M. Blair, Vice President of Panellit Services Corporation, will discuss Contract Instrument Maintenance.

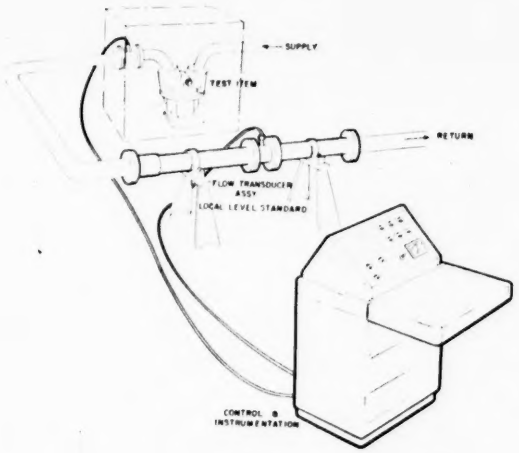

FIG. 1. CALIBRATION STAND at local standards laboratory compares test item (top) with reference standard that is calibrated at secondary standards laboratory. (Illustrations are courtesy of Potter Pacific Corp., Malibu, Calif.)

ture. Standards for this laboratory are calibrated by the National Bureau of Standards directly through the use of transfer standards. A transfer standard is an instrument specifically designed to carry the accuracy of calibration from the laboratory of higher echelon to the one next lower in the structure. Because of the minimum accuracy ratio existing between the two laboratories, occasions arise where the transfer standards also become the reference standards for the laboratory at the lower echelon. The minimum allowable ratio of accuracy between echelons has been established at four to one (for most measurements).

Of all of the establishments participating in this program, only the primary standards laboratory sends instruments to the National Bureau of Standards for calibration and certification. The National Bureau of Standards is thereby relieved of a large load of routine calibrations on lower-accuracy-level instruments for the Naval Bureau of Ordnance.

Standards found in the primary standards laboratory include saturated standard cells in an air bath, a static-type liquid flow calibration facility, a 0.025% pressure balance with total capacity of 200,000 psi, and many others embracing the fields of force, mass, acceleration, electricity, electronics, and microwaves.

Secondary Standards Laboratory

Each primary standards laboratory services a number of *secondary standards laboratories*, and all calibrations and certifications for this group of secondary laboratories are performed by its cognizant primary laboratory. Secondary standards laboratories are placed in Naval establishments such as quality evaluation laboratories and contractors' plants requiring secondary-level calibration services. Each secondary standards laboratory services a much smaller geographical area than the primary standards laboratory; therefore, measurements covered by the secondary laboratory are much more specialized. After a careful survey of the geographical area under the cognizance of the secondary standards laboratory it determines those areas of measurement for which standards must be furnished. This secondary laboratory then furnishes calibration services only in those measurement areas.

Local Standards Laboratory

The laboratory at the lowest echelon of accuracy in the system is designated the *local standards laboratory*. This laboratory calibrates the working-level instruments within its area of cognizance; therefore the local standards laboratory is highly specialized and designed only for the particular needs of the individual establishment in which it is located. Such laboratories can be found in contractor's and subcontractor's plants, or in the Naval Bureau of Ordnance establishments where only specialized working-level instruments are used in testing. Although the local-level reference standard is calibrated under controlled conditions at the secondary standards laboratory, a controlled environment is not employed at the local standard laboratory level.

Program Direction

The Measurement Standards Division of the Naval Inspector of Ordnance at Pomona provides technical direction of the BuOrd Calibration Program. As outlined in the task assignment by the Naval Bureau of Ordnance, it is the responsibility of this division to undertake and accomplish the following:

1. Select and designate specific and proper reference and transfer standards and associated equipments, evaluating these equipments to assure high quality selections.

2. Coordinate the documentation of, and prepare where necessary, the detailed calibration and certification procedures and techniques.

3. Designate the calibration and certification periods for reference and transfer standards and associated equipment.

4. Devise and establish an appropriate calibration data reporting and analysis system to provide for any revision to calibration periods and changes to procedures, techniques, equipment, etc., necessary to the continued improvement of the calibration program.

5. Determine and recommend locations for, and the relative status of, standards laboratories—giving major consideration to existing facilities, workload, economics, and the technical requirements of each.

6. Provide for the necessary technical coordination among standards laboratories and program of other agencies to assure compatible operational philosophies and the dissemination of available technical information.

7. Monitor new developments in standards, calibration equipment and techniques and, where technical requirements of the program dictate, develop and

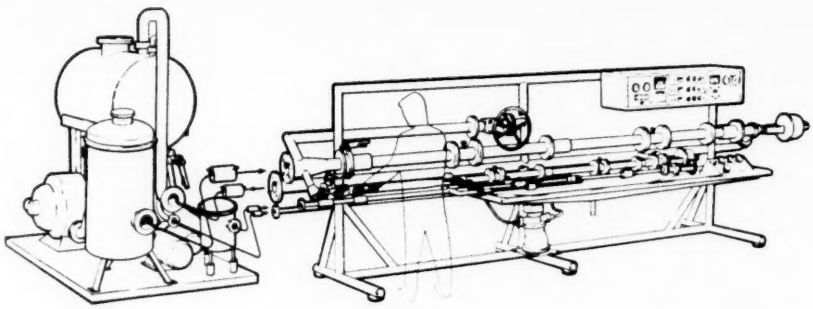

FIG. 2. CALIBRATION STAND at secondary standards laboratory also is comparison type. Standard is calibrated at primary standards laboratory.

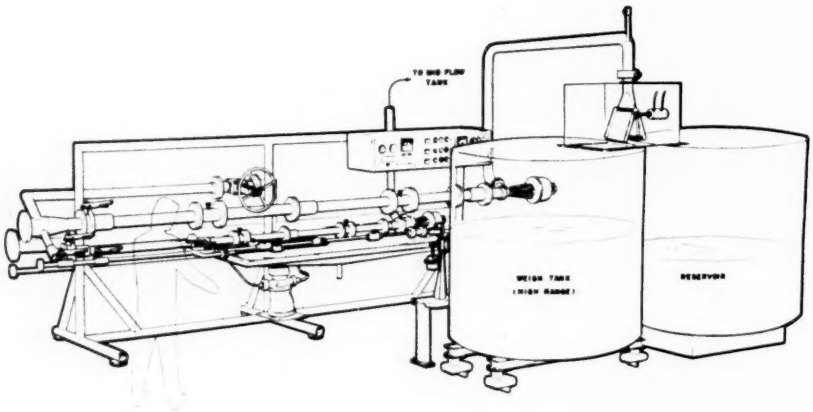

FIG. 3. CALIBRATION STAND at primary standards laboratory uses static-type weigh-tank calibrator. National Bureau of Standards services only this one laboratory.

construct the necessary reference and transfer standards.

8. Provide for necessary packaging and shipping systems to assure safe transit environment for all transfer standards.

9. Provide for the necessary training of standards laboratory personnel in techniques, procedures, laboratory operation, calibration philosophies and scope of program.

Fluid Metering

Fluid metering in the BuOrd Calibration Program is divided into two basic areas—(1) the metering of incompressible fluids (liquids) and (2) the metering of compressible fluids.

The calibration of *liquid metering devices* is a straightforward process at industry level. As accuracy requirements have increased, however, problems considered insignificant at the industry level have become matters for careful consideration. Present accuracy requirements for liquid flow measurement at industry level are such that the BuOrd Calibration Program is required to maintain the following:

1. *Local Standards Laboratory Level.*

A. A system accuracy of 0.5% must be maintained at the local standards laboratory to maintain successfully the calibration of working instruments at the industrial level.

B. Range requirements of flow measurement vary with each of the local standards laboratories because of the specialization of the laboratories at this level and also because of the small geographical area under the cognizance of the laboratory. Although the total range of flows to be considered by the BuOrd Calibration Program extends from 15 to 2,500,000 pounds per hour, the local laboratories will be required to maintain only those meters necessary to meet the requirements in that location.

C. The local liquid flow standard, as it is now specified, is a comparison-type system. Generally the calibration is performed by connecting the standard into the line in series with the working-level instrument (Fig. 1). The source of supply for both instruments is the one which normally furnishes motive power for the liquid medium in the working-level system. This specifies, therefore, that the calibration is made under the actual operating conditions of the working-level instrument.

D. Because of the small ratio differential between industry requirements and the capability of the National Bureau of Standards, it has been found impossible to carry out the prescribed minimum accuracy ratios of 4 to 1 between laboratories in the program. The secondary standards laboratory, therefore, maintains only a system accuracy of 0.2%.

2. *Secondary Standards Laboratory Level.*

A. It has been the policy of the BuOrd Program to take accuracy losses at the lowest echelon possible because an accuracy loss within greater tolerance limits is not as critical as at the primary and secondary laboratories. Therefore, calibrations at the secondary standards laboratory are made both under standard conditions within the calibrating system and under controlled environmental conditions.

B. The secondary liquid flow standard, as it is now specified, is also a comparison-type system (Fig. 2). This system comprises the standard instrument, the lead-in and lead-out sections, a source of liquid power, and the necessary indication instrumentation.

3. *Primary Standards Laboratory Level.*

A. The accuracy requirement at the primary standards laboratory demands that flow measurement be made in the basic units of weight and time. Measurement of fluid in these basic units has been reduced to the finest of measurements possible. It is, therefore, imperative that a means be devised by which the measurement of incompressible fluid (liquid) flow be reduced to these units. Hence, the primary liquid flow standard is designated a static-type weigh-tank calibrator.

B. This calibrator (Fig. 3) uses a diverter-valve-type of shut-off allowing the pumping unit to run continuously while allowing a "static" weighing of the liquid in the tank. The diverter valve assembly is mechanically connected to the timer-counter circuit. The timer-counter consists of an electronic counter incorporated with a timing device based on a 5-kc crystal which, in turn, is calibrated against WWV.

Compressible Fluids

In the area of compressible fluid flow, problems exist in addition to those which are encountered in the measurement of incompressible fluid flows. These problems are as many and as complex as the number of conditions under which such flow measurements must be made. The Bureau of Ordnance is advancing into the field of compressible fluid flow rather slowly in order to make certain that accurate and reliable means are used to calibrate these flows.

Consideration is being given to relating the local standard to the range of conditions in which it is to be used. For instance, at low flow rates and at pressures near ambient such instruments as wet-test meters and gasometers are being investigated. In the area up to the point where the development of shock waves in the sensing element interferes, differential-pressure-types of measuring devices are being considered. The accuracy which must be maintained at the local level laboratory to meet industry parameter requirements is at least 1%.

Tests have just been completed on a plenum-chamber-type of air-flow measuring device at the secondary standards level. The particular system which was tested has a flow range from 8 to 150 scfm. Through the use of the plenum chamber and standard nozzles these flows can be measured at line pressures up to 900 psi. At present it is expected that the system accuracy of the equipment will be 0.4%.

Little consideration has been given to a primary standard, except to make the determination of accuracy which must be met at this level. To adequately meet the needs of industry and to carry out recommended ratios of difference between laboratory levels the accuracy of the primary standard must have a system accuracy of no less than 0.1%

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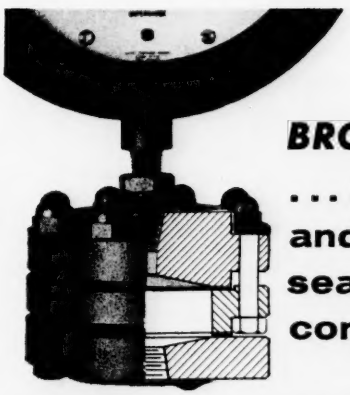

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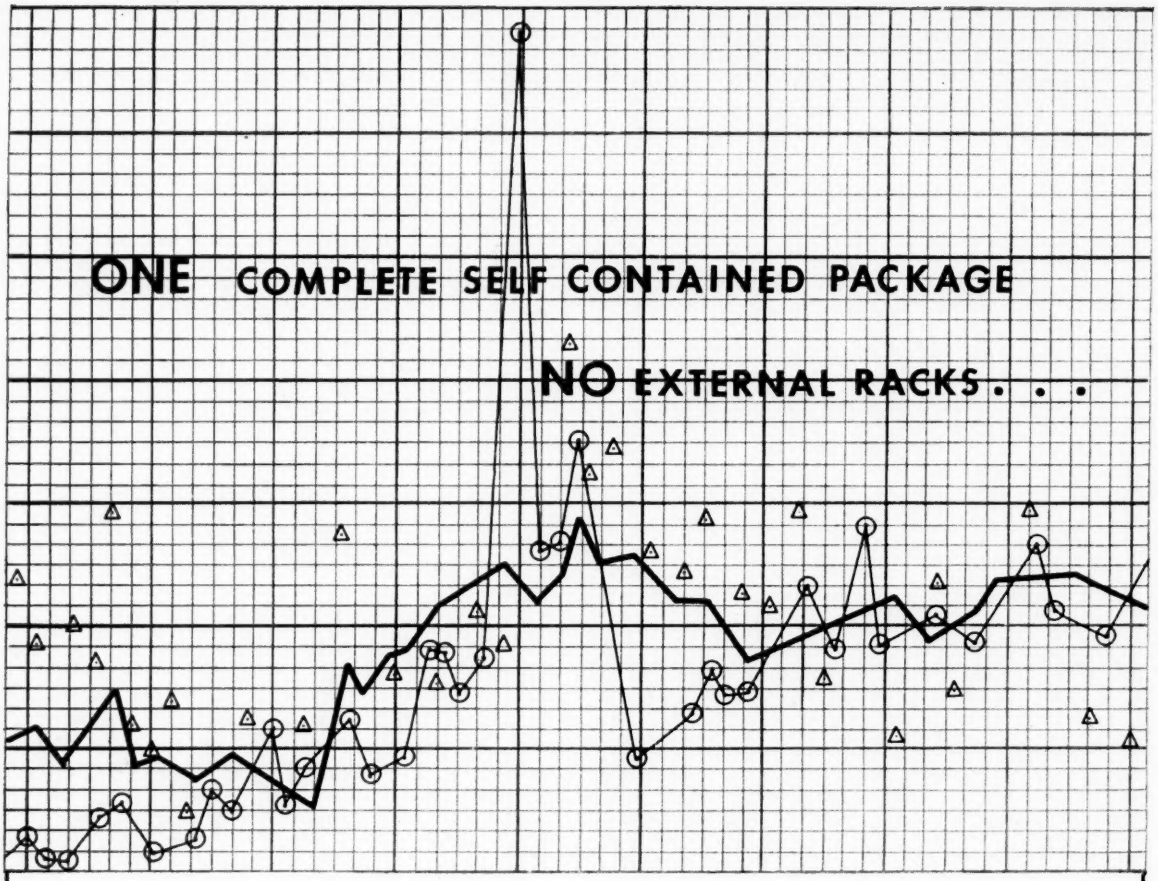

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Points and symbols: Up to 50 points per minute.
Continuous line: Up to 25 points per minute.

Output Accuracy

Points or symbols: 0.05% of full scale.
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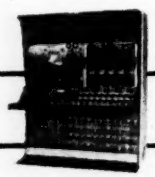

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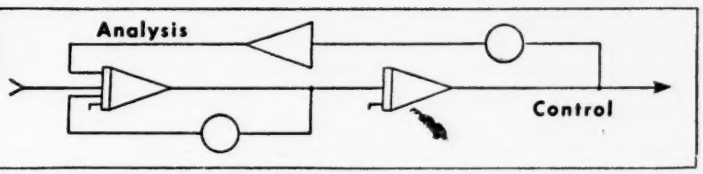

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Bits

This month name your problem and the panel experts quoted under Pieces will tell you the kind of computer to use—and why:

Pieces

WS/C AND DDA COUNCIL MEETING OF 5 MAY ON "PROBLEMS UNIQUE TO COMPUTERS OF A KIND"

Over 70 representatives of more than 32 different organizations gathered—after much confusion caused by a last-minute change of meeting room—at the California Institute of Technology in Pasadena on the afternoon of 5 May 1958. It was planned that a panel of five men—selected for their proficiency with five different kinds of computers—would present the case for each kind and precipitate a lively discussion from the floor. However, all panel members did such a thorough job that the audience was left with little time or inclination to participate.

Goldberg on Active Real-Time EDA's

First on the panel was *E. A. Goldberg* (Ramo-Wooldridge Corp., Los Angeles 45, Calif.), who spoke on the type of computer which is probably the most widely used at present for simulation—the active Electronic Differential Analyzer.

The real-time, active analog computer proves to be most useful for the solution of problems which can be described by simultaneous differential equations, linear or non-linear, with constant or variable coefficients, particularly servomechanism analysis and design problems.

To illustrate, Mr. Goldberg discussed the simulation of a hydraulic servomechanism on an Electronic Associates analog computer, to determine the effect of certain non-linearities upon the frequency and transient response of the servo.

One important characteristic of real-time active analog computers is that they can be used in physical simulation; thus it is not necessary to obtain analytic relationships for the entire system under consideration.

Figure 1 presents a block diagram of the servo system which was simulated. The dynamics of the motor-gimbal assembly, piston, and oil were included in the simulation. Two important non-linearities were also included—(1) coulomb friction in the gimbal and (2) the non-linear flow relationship of the flow-control valve.

A schematic diagram of the flow-control valve and piston assembly, which introduce the most important non-linearities, appears in Figure 2.

Operation of the valve is as follows: As a first approximation the amount of flow going through the orifices of the valve assembly is proportional to the displacement. As the

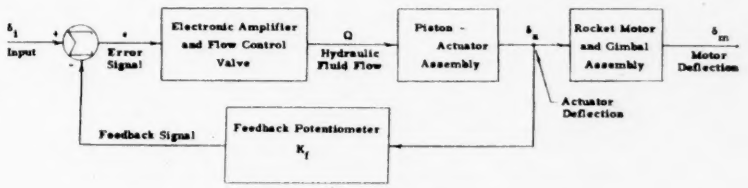


Fig. 1. Block diagram of hydraulic servomechanism.

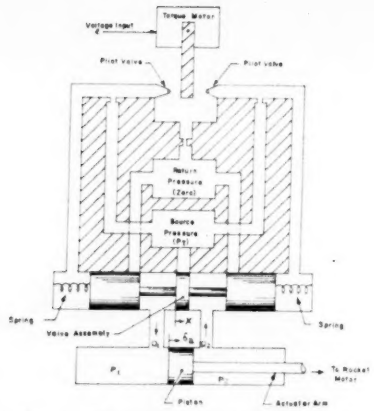


Fig. 2. Flow control valve and piston assembly.

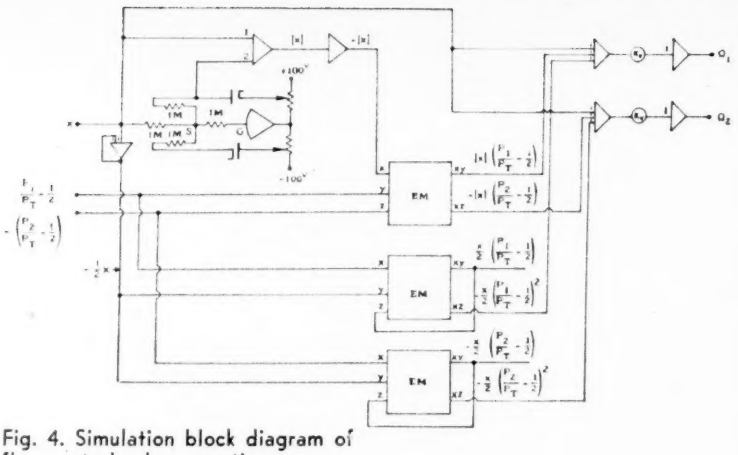


Fig. 4. Simulation block diagram of flow-control-valve equations.

$$Q_1 = \begin{cases} K_v \sqrt{\frac{1}{P_T}} \left[x \sqrt{P_T - P_1} \right], & x \geq 0 \\ K_v \sqrt{\frac{1}{P_T}} \left[x \sqrt{P_1} \right], & x \leq 0 \end{cases}$$

$$Q_2 = \begin{cases} K_v \sqrt{\frac{1}{P_T}} \left[x \sqrt{P_2} \right], & x \geq 0 \\ K_v \sqrt{\frac{1}{P_T}} \left[x \sqrt{P_T - P_2} \right], & x \leq 0 \end{cases}$$

$$Q_1 = K_v \left[x + |x| \left(\frac{P_1}{P_T} - \frac{1}{2} \right) - \frac{x}{2} \left(\frac{P_1}{P_T} - \frac{1}{2} \right)^2 \right]$$

$$Q_2 = K_v \left[x + |x| \left(\frac{P_2}{P_T} - \frac{1}{2} \right) - \frac{x}{2} \left(\frac{P_2}{P_T} - \frac{1}{2} \right)^2 \right]$$

Fig. 3. Flow-control-valve porting equations.

dynamics of the torque motor, pilot valve, and valve assembly involve only very high-frequency effects, they can be neglected. Thus the flow, and therefore velocity of the piston, is approximately proportional to the input voltage.

Actually the flow through the porting orifices is not independent of the pressure across them. This produces a non-linear effect which is sometimes termed "valve loading." Analytically, valve loading is described by the fact that flow through an orifice is proportional to the product of cross-sectional area and the square root of the pressure drop across the orifice. The effect of this non-linearity was included in the simulation.

Figure 3 gives the flow-control-valve porting equations. Q_1 and Q_2 are the flows on either side of the piston; P_1 and P_2 are the pressures on either side of the piston; P_T is the source pressure: the return pressure is zero. Simulating these equations requires switching logic and square-rooting circuits. The task of simulation can be simplified greatly by writing the square root terms as a Taylor's series. A block diagram for the simulation of these equations is shown in Figure 4. The $|x|$ is generated with diodes and two operational amplifiers: relay circuitry could have been used. The non-linear terms of the flow equations are obtained by electronic multiplication.

The equations which describe the dynamics of the rest of the servomechanism appear in Figure 5. The two flow equations show that part of the total flow goes into moving the piston, the δ_a term, and part goes into compressing the oil, the $\dot{P}$ term. Another term could be added to account for leakage flow around the piston. A is the area of the piston; V is the volume of hydraulic fluid on each side of the piston; E is the bulk modulus of the hydraulic fluid; δ_a is the actuator deflection. An $F = ma$ equation is written for the piston dynamics. M_P is the mass of the piston; K_P is the (linear) piston damping; K_s is the actuator arm spring constant. The motor equation sums the torque around the gimbal. I_m is the motor's inertia around the gimbal; δ_m is the motor deflection; r is the distance between the actuator attach point on the motor and the gimbal; B_{fv} is the linear friction in the gimbal; B_{fc} is the coulomb friction in the gimbal. The feedback equation is straightforward.

These dynamic equations were simulated with normal operational amplifier circuitry. The total simulation (including the flow equations) required 26 amplifiers and three electronic multipliers.

Piston-Actuator Equations

$$Q_1 = A \dot{\delta}_a + \frac{V}{E} \dot{P}_1$$

$$Q_2 = A \dot{\delta}_a + \frac{V}{E} \dot{P}_2$$

$$M_p \ddot{\delta}_a + K_p \dot{\delta}_a + K_s (\delta_a - \delta_m) = A (P_1 - P_2)$$

Motor Equation

$$\frac{I_m}{r} \ddot{\delta}_m + B_{fv} \dot{\delta}_m + B_{fc} = K_s r (\delta_a - \delta_m)$$

Feedback Equations

$$\epsilon = \delta_i - K_f \delta_a$$

$$x = K_a \epsilon$$

Fig. 5. Servomechanism dynamics.

The effect of the two non-linearities upon transient and frequency response was recorded by Electronic Associates x-y plotters and Mid-Century 6-channel recorders. Typical examples of transient responses taken from the x-y plotters appear in Figure 6. These show the effect of different magnitude step inputs with valve loading, but no coulomb friction. Notice that as the step magnitude is increased the response appears more heavily damped. Such responses were obtained for various system parameters.

Because this servo system is only part of an autopilot loop, the effect

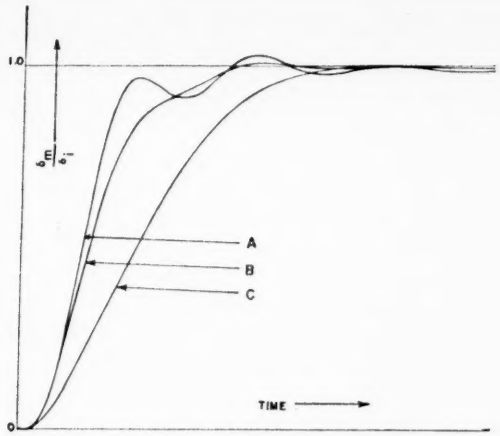


Fig. 6. Transient response to step function. In curve A, δ_i is a small step; in curve B, δ_i = 0.02 radian (1.15°) step; in C, δ_i = 0.1 radian (5.73°) step.

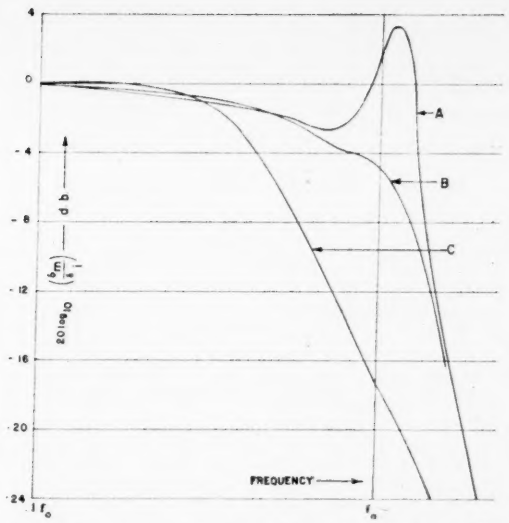


Fig. 7. Frequency response of hydraulic system with viscous friction. Curve A is unloaded case where δ_i = 0; in curve B, δ_i (peak) = 0.02 radian = 1.15°; in Curve C, δ_i (peak) = 0.1 radian = 5.73°.

of the non-linearities upon frequency response is important. Typical plots showing this are reproduced in Figure 7. Data for these plots were taken from waveforms plotted on the recorders. The amplitudes are from peak measurements; the phase shifts from zero crossings.

Levine on High-Speed Repetitive EDA's

Leon Levine (Hughes Aircraft, Culver City) presented the case for the High-Speed Repetitive Electronic Differential Analyzer, as produced by GPS and Philbrick.

Leon pointed out that two ways to save time on long problems are (1) to change the time scaling (i.e., reduce the time required to produce a solution) and (2) to devise a program which will minimize the number of solutions required. The high-speed repetitive computer, which can produce solutions several hundred times as quickly as the type of differential analyzer described by Mr. Goldberg, is particularly well suited to the first course of action. If a large number of runs is needed, as required for statistical studies, techniques like the adjoint method (developed by Laning and Battin and described in Proceedings of the 1952 Cyclone Symposium) may be used to cut the number of runs, provided the problem is linear and the noise Gaussian.

In general, however, if the problem is non-linear, or even if it is linear and the noise is not Gaussian, the "brute-force" method must be used. This makes it even more important to reduce the time per solution. And because the uncertainty in specifying mean and standard deviations varies inversely as the square-root of the number of runs, to double the accuracy would require four times the number of runs, and a still higher premium is placed on time of solution. Such a problem is made to order for high-speed repetitive computers.

Leon paid compliments to the GPS computer and the new chopper-stabilized Philbrick. However, as he had more experience with the GPS he chose to describe the latter, which he did as follows:

A. Time-scale can be compressed 3000 to 1.

B. It has repetitive speeds up to 60 cps.

C. It has some conventional elements—amplifiers, integrators, and scale-factor pots.

D. It is scaled and programmed like a regular analog computer.

E. Servos cannot be used because of high speed, so diode shaping networks and quarter-square multipliers are used.

F. High frequencies also preclude pre-patching, so telephone-type cords and plugs are used to connect directly to computing elements.

G. Data are presented on an oscilloscope which has the z-axis modulated to produce time-dots every 0.2 second, and a calibrated line to measure accurately the value of the function.

Leon said anyone familiar with analog computers can learn to run the high-speed variety with almost no additional training.

As a case history he told about a study which took four months on an old REAC; it would probably take ten weeks on a new one, making 100 runs for each point. By working for one week at the GSP laboratory in Newton, Massachusetts, two men got the probability distribution using 500 runs each and 5 points to define a sample—about 25 times as much data as was previously obtained. And then the limiting factor was not the computer but the ability of the operator to assimilate the data. With almost no extra effort they used a memoscope to obtain two-dimensional distributions.

The total cost was about $3,000, including round-trip plane fare for two from Los Angeles. The results checked with the REAC results to within 4% and with themselves to 1%. Rental for a real-time computer for the job would have cost from $20,000 to $30,000.

Another cogent point that Leon brought out in favor of the high-speed computer was the psychological and morale effects of long, repetitious problems on personnel. The complexity of such a problem usually requires the assignment of a highly-trained computer engineer. Yet such a person will almost certainly suffer from boredom, and mistakes and low morale will follow. There is also greater likelihood of machine failure.

Leon's talk moved *Dov Abramis* (Convair, Pomona, Calif.) to comment that attempts to use a high-speed repetitive type of computer at

Pomona had been "one big fizzle." Perhaps Dov does not have many of the kind of problems Leon described. However, there is undoubtedly some prejudice involved, too. Computer operators, having some of the same characteristics as people, are apt to distrust things that are a bit different.

Dixon on Direct Analog Computers for Structural Dynamics

The third speaker was *W. J. Dixon* (Computer Engineering Associates, Pasadena, California), who opened by saying that his company has a virtual monopoly on a certain kind of computer which is particularly well adapted to the solution of a certain class of problems—the Direct Analog Electronic Computer for the study of Structural Dynamics.

To sell his point Bill drew his example from a paper "Direct Analog Method of Analysis of the Vertical Flight Dynamic Characteristics of the Lifting Rotor with Floating Hub" by *R. H. MacNeal.** In this paper application of the direct analog computer method to the analysis of helicopter rotors in vertical flight is described. The basic component in the electrical model of a rotor blade is the analogy for the vibration of beams. To this are added electrical circuits that simulate the effects of centrifugal forces, inertia forces, Coriolis forces, aerodynamic forces, control mechanisms, etc. The completed electrical model permits the direct simulation of such conditions as flutter, transient response to controlled changes in cyclic pitch, and dynamic response to harmonic load variations.

Both the paper and the Simulation Council presentation are too detailed for presentation here. However, a few extracts and a few diagrams will suffice to show that Bill made his point.

"The direct analog computer consists of an assemblage of passive electrical circuit elements (resistors, capacitors, inductors and transformers), amplifiers, signal generators and control equipment. Its principles of operation arise from an identity in form (analogy) between electrical circuit equations and the equations of other kinds of physical systems. The electrical analogy for the bending of beams has great importance in the direct analog method of dynamic analysis for lifting surfaces, since many lifting surfaces can be replaced by lifting lines with bending and torsional flexibility. This is certainly true of the helicopter rotor blade which characteristically has a very large span-to-chord ratio.

"Although the electrical beam analogy is a basic ingredient of the direct analog method for both conventional lifting surfaces and helicopter rotor blades, there are many significant differences which occur in the analysis of these two types of lifting surfaces, and these differences require different arrangements of electrical circuit elements.

"In the case of the helicopter some simplifications are possible, but these are more than offset by the following added complications:

1. The rotor blade is operating in a strong centrifugal force field which gives rise to a number of important dynamic effects.
2. Due to the high span-to-chord ratio, the in-plane bending flexibility of the blade cannot be ignored for many purposes.
3. The blade is hinged at the hub to permit free flapping motion and also, usually, free lagging motion.
4. Forward translation of the rotor as a whole gives rise to periodically varying aerodynamic coefficients and periodically varying air loads on each rotor blade.
5. Even for vertical or hovering flight, the freedom of the rotor blade to vibrate in its own plane may give rise to important aerodynamic effects.
6. For low inflow velocities, blade to blade wake-induced coupling effects may be important.
7. Control is effected through pitching motion of the whole blade rather than by the use of flaps. Details of the control mechanism must usually be considered.
8. The rotating rotor is dynamically coupled to a stationary fuselage by means of a flexible pylon."

A plan view of a helicopter rotor with the details of one blade appears in Figure 8. A side view of the rotor is shown in Figure 9.

In the direct analog method of analysis used in the illustration, electrical currents are made analogous to forces, and voltages are made analogous to velocities. The principles used to construct an electrical analogy of a mechanical system are explained with reference to the simple mechanical and electrical systems shown in Figure 10.

One method of establishing an analogy would be to write complete sets of equations for each system and to identify corresponding terms and coefficients in the equations. This method was not used because it is desirable, in the long run, to avoid writing equations when it is not necessary to do so and also because the analogy between mechanical and electrical systems is not completely revealed by a purely algebraic formulation. We start by observing that each system is composed of a number of simple parts. Individually, each part is defined by relationships

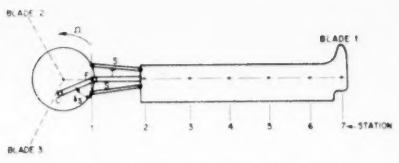


Fig. 8. Plan view of one blade of helicopter rotor.

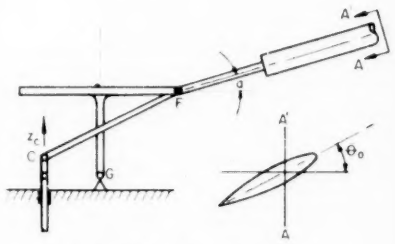


Fig. 9. Side view of rotor.

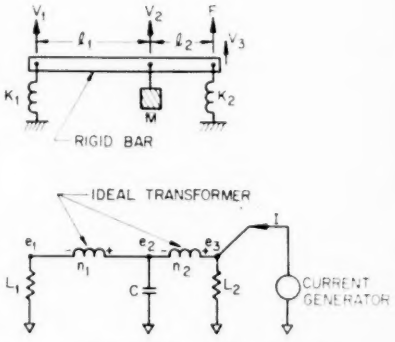


Fig. 10. Basic analogy between mechanical and electrical systems.

*Presented at the 26th Annual Meeting of the Institute of Aeronautical Sciences, January 1958; Preprint #806.

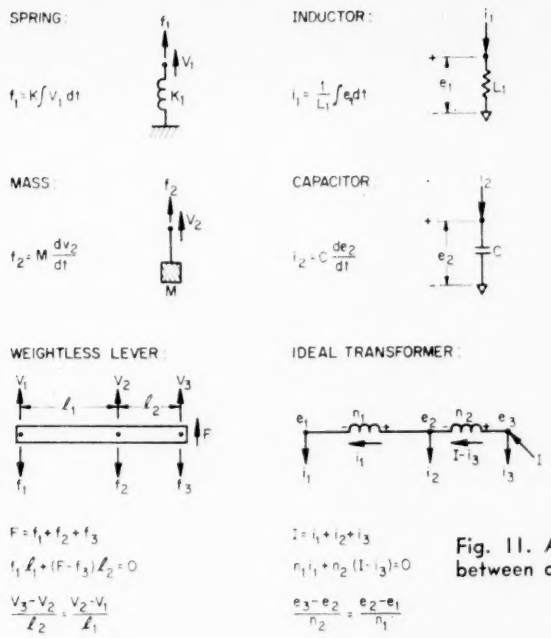

SPRING:
$f_1 = K\int V_1\,dt$
INDUCTOR:
$i_1 = \frac{1}{L_1}\int e_1 dt$
MASS:
$f_2 = M\frac{dv_2}{dt}$
CAPACITOR:
$i_2 = C\frac{de_2}{dt}$
WEIGHTLESS LEVER:
$F = f_1 + f_2 + f_3$
$f_1\ell_1 + (F - f_3)\ell_2 = 0$
$\frac{V_3 - V_2}{\ell_2} = \frac{V_2 - V_1}{\ell_1}$
IDEAL TRANSFORMER:
$I = i_1 + i_2 + i_3$
$n_1 i_1 + n_2 (I - i_3) = 0$
$\frac{e_3 - e_2}{n_2} = \frac{e_2 - e_1}{n_1}$

Fig. 11. Analogies between components.

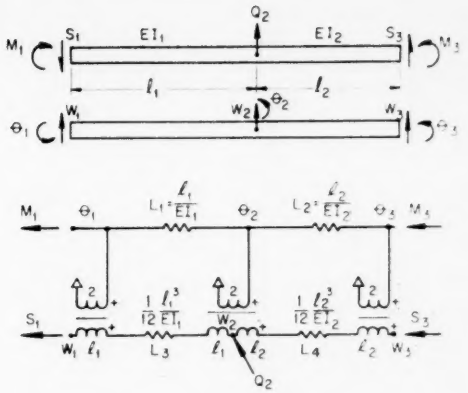


Fig. 12. Beam analogy.

between physical quantities existing at its "terminals." If corresponding parts in the two systems are paired, as shown in Figure 11, the identity in form of these relationships is easily established. This results in the list of formal analogy relationships shown in Table I.

Table I

Mechanical Quantity	Electrical Quantity
Velocity, V	Voltage, e
Force, f	Current, i
Spring, K	Inductor, 1/L
Mass, M	Capacitor, C
Damper, B	Resistor, 1/R
Lever ratio, ℓ_2/ℓ_1	Transformer turns ratio, n_2/n_1

The next step is to verify that the additional relationships which are satisfied by the parts when they are connected together are also identical in form. In the mechanical system, where two parts are joined together, their velocities are equal and the sum of forces acting on the junction is zero. In the electrical system, where two parts are joined together, their voltages are equal and the sum of currents entering the junction is zero.

The relationships between forces at a point of interconnection can be derived from the relationships between velocities and the statement that the forces acting on the point of interconnection do no work. Similarly, the relationship between currents at an electrical junction can be derived from the relationship between voltages and the statement that the net power absorbed by the junction is zero. Since it can be assumed that all mechanical interconnections are workless and that all electrical connections are good short circuits, it is necessary only to demonstrate that the relationships between terminal voltages are identical to the relationships between corresponding terminal velocities. In the example of Figure 10 this analogy is self-evident.

The method described can be extended immediately to any mechanical system consisting of a combination of springs, masses, dampers and simple rigid levers. More complicated elements, such as beams with flexural rigidity, can be included either by treating them as components with somewhat more complicated relationships between the quantities existing at their terminals or by replacing them by an equivalent set of simpler elements.

The form of the beam analogy used is shown in Figure 12.

By judicious extrapolation of this technique to significant details of the rotor dynamics, the complete circuit for one rotor was derived, as shown in Figure 13.

Rutishauser on the DDA

Rudolph Rutishauser (Litton Industries, Beverly Hills, Calif.), who spoke next on "The Digital Differential Analyzer and Its Application," also noted that unfamiliarity breeds contempt.

The DDA, said Rudolph, is not just a computer; its operational characteristics are also applicable to systems control. When DDA techniques are employed in a systems computer, the machine is generally referred to as an *incremental computer*. The capabilities of DDA's and incremental computers have not been widely publicized, and individuals are apt to be biased against them by their experience and understanding of equipment with which they are familiar.

Analog equipment is ideally suited to many problems where limited accuracy and solution time are involved; however, consider such problems as inertial guidance where the period of the earth pendulum is 84 minutes. Analog equipment should not be employed because the accuracy is limited and the time factors are too long.

As the complexity and non-linearity of problems increase, the DDA becomes more and more powerful for three basic reasons: (1) by time sharing, component count need not increase in the same proportion as problem complexity; (2) accuracy does not decrease as complexity increases; and (3) because of the characteristics of the digital integrators, integrator count versus amplifier count tends to favor integrators. (For small problems, however, the analog is favored.)

The general-purpose digital computer is still an arithmetic computer —there is no sophistication directed toward its scientific application. This is because of the large number of applications to business, which have influenced the design.

Where computers must travel with a system—primarily airborne sys-

tems—the general-purpose digital and analog computers become prohibitive in size, and the best recourse is to incremental computers.

One type of problem which was solved on analog equipment, on an IBM 701, a desk calculator, and a DDA—and for which some figures can be given—is described by the following integral equation:

$$I = \int_{10}^{30} ydx, \text{ where y is the solution to}$$

$$x^2\ddot{y} + [x^2 - n(n+1)]\,y = 0$$

The analog was limited to about 1% accuracy; the arithmetic computer required in the order of two-weeks' programming time; the desk calculation took one month; and the DDA solution was obtained in two hours—to an accuracy of 0.1%. Mr. Rutishauser explained that he could not divulge the cost, but it was definitely in favor of the DDA unless the number of solutions became extremely large.

He went on to say that there are innumerable situations where, because of the ease in generating the solutions, the DDA should be used. Every day new ways are found to generate solutions to equations which previously had not seemed amenable to solution by the DDA.

Sonheim on Simulation by Digital Computer

The last panel member was *Daniel Sonheim* (Convair, San Diego, Calif.), who spoke on "Aerodynamic Flight Simulation on a General-Purpose Digital Computer."

The problem as originally proposed by the aerodynamics section was that they wanted to "fly a black box." Given the lift, drag, and thrust vectors and using standard equations of stability they wanted such output information as they might choose to specify. They wished to be able to fly the vehicle in such a way that they could make a mission or a parameter study.

A mission may be defined as a sequence of flight simulations or phases to be computed in one machine run. For example, the program might be called upon to simulate an airplane which takes off, climbs to cruise altitude, cruises at this altitude for a specified interval of time, fuel, or distance, does some maneuver, and then returns to base. The program is to produce output information at specified intervals of time, distance, mach number, or other factors, throughout the mission.

The equations of motion are solved by the program for a particular set of airplane specifications like wing area, weight, thrust, drag, velocity, altitude, temperature, and others.

A program of such scope and flexibility best lends itself for solution on a large General-Purpose Digital Computer. The following is presented to give better insight into the extent of the program.

1. The number of input variables may be large (more than 150 values), with 3 thrust sources possible.
2. The program must be so general and adaptable that if some of the input is not specified, the system will compute the values on the basis of available information.
3. The system has the ability to do 4-point Lagrangian table look-up on a one-, two- or three-variable table, or find a value by polynomial approximation. Tables having discontinuities are to be provided for.
4. As a result of the extensive provision for flexibility, the number of logical decisions far exceeds the algebraic operations.
5. Output is required in punched-card form for plotting purposes, as well as variable printed output. The interval as well as amount of output may be specified by codes.
6. By means of code words fol-

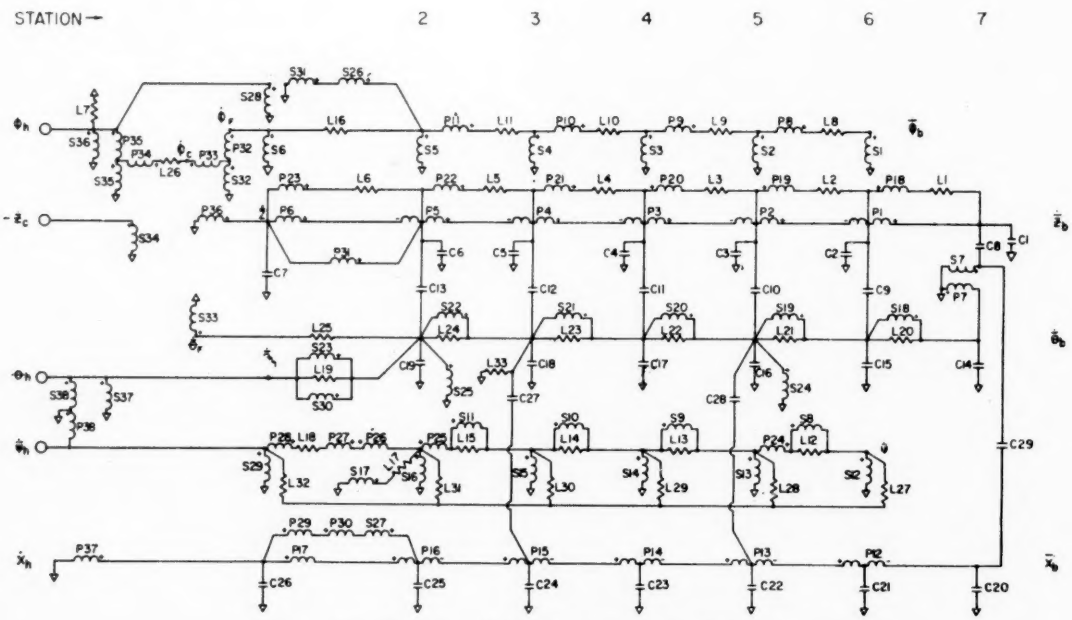


Fig. 13. Complete circuit for structure of one blade.

lowed by values, the Engineer may specify up to four termination conditions of a flight simulation or study. The first termination condition that is satisfied causes termination of all.

7. Range of variation in magnitude of values is such that floating point arithmetic must be employed.

Sources of information may be divided into three main groups:

1. *Airplane data*
   (a) Wind tunnel test data
   (b) Flight test information
   (c) Physical data peculiar to a particular airplane
2. *Engine data*
   (a) Engine manufacturer
   (b) Fuel flow and thrust data
   (c) Physical data about a given engine
3. *Atmospheric data* (standard, cold day, or hot day)
   (a) Temperature variation with altitude
   (b) Velocity of sound variation with altitude
   (c) Pressure variation with altitude

The following phases of flight simulation are now in use or available:

1. Acceleration
2. Climb
3. Cruise
4. Maneuvers
   (a) Pullup (variable a, constant load factor)
   (b) Theta (constant theta)
   (c) Zoom (constant γ)
   (d) Wind up turn
5. Cruise as a parameter study
6. Loiter
7. Engine parameter studies
8. Speed altitude envelope

Information (Without Theory)

In the April issue of *I&A*, under Info in the *Newsletter*, we described a publication on computers to be put out by Iota Services Ltd., 38 Farringdon St., London E.C. 4, England. We mention this again because we have just received our first specimen copy, and if their coverage of the field in general is as informative and accurate as their two references to the *Newsletter*, it is a fine source of information indeed. This particular issue listed and annotated 131 papers, articles and books; seven patents; eight meetings; two courses; and seven pieces of trade literature dealing with computers. Subscription rate in the U.S. is $20 per annum.

* * *

It is perhaps no accident that just as we were writing up *Leon Levine's* case for the high-speed repetitive computer (see Pieces), we received a letter from *Samuel Giser* of GPS Instrument Co. (Newton, Mass.) which says in part:

"The GPS Statistical Computer was designed specifically for application with the GPS Repetitive Analog Computer. Its uniqueness is dependent on the rapid-rate, repetitive solution of the simulated problem. The analog rate is variable from 10 to 60 complete solutions per second; a factor of 3000 times greater than the real time history. It follows, therefore, that for a statistical *point* analysis, as many as 3600 solutions, or events in an ensemble, can be sampled in one minute of time. The complete probability distribution of the random variable can be plotted in several minutes.

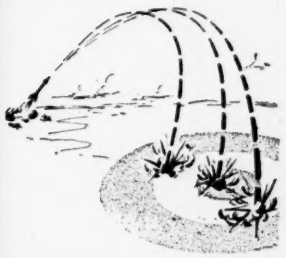
"The requirement for such a statistical computer was generated principally by the aircraft industry. The specific area requiring high-speed computation was the calculation of the statistical properties of miss distance of an interceptor missile, which leads directly to such operational indices as kill probability and mission success or failure. The GPS Statistical Computer performs these calculations with high statistical confidence, in a period of time which is extremely short relative to other existing methods, either digital or analog. As a matter of fact, since the statistical properties of a variable can be quickly and easily monitored, these are now being used directly to *truly* optimalize the performance of a control system.

"The applicability of the GPS Statistical Computer is not at all limited to missile problems. It must certainly be true that

Brainwashing—USA

ARE any new fields of computation opened up by the GPS High Speed Analog Computer?

YES, the statistical evaluation of the performance of systems perturbated by random noise can now be accomplished at high speed. With the system simulated on a



high speed computer such that the solution is carried out several thousand times faster than real time, samples of a random variable such as the miss distance of a missile system can be taken at rates up to 50 per second. Thus, sample sizes of several hundred can be taken in a few seconds' time.

GPS has a complete line of equipment to generate random noise for introduction to the system and to monitor the output. RMS values of random variables can be measured directly and complete probability distribution functions can be determined with statistical confidence in a matter of minutes.

IF you have problems requiring immediate analysis, the GPS Computer Center in Newton can provide analog facilities and experienced engineering assistance to suit your needs.

ANALOG COMPUTERS

For further information write Department 11

GPS **INSTRUMENT CO. Inc.**

180 Needham Street

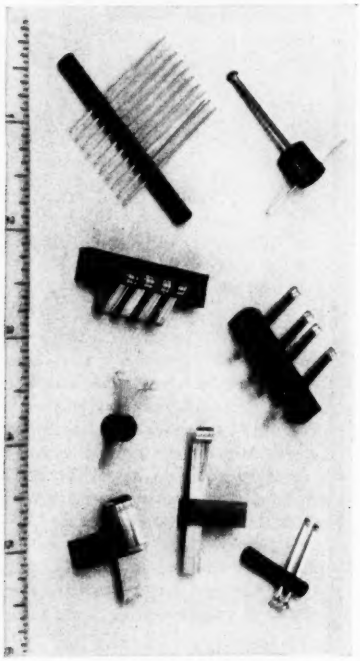
Newton 64, Massachusetts

DEcatur 2-8110

For more information circle **62** on inquiry card.

announcing

NEY MOLDED CONTACT ASSEMBLIES



Impressive cost savings and greater reliability are inherent in the use of the new Ney molded contact assemblies. For use with printed commutators, potentiometer windings, slip ring assemblies and printed rotary switches, these assemblies are available in a standard line now being manufactured by Ney, or can be designed to customer specifications.

Seven prime advantages are (1) a complete single or multiple brush assembly ready to use, (2) no welding or soldering, (3) reduction of adjustment during assembly into unit, (4) insured uniformity of desired gram pressure, (5) reduced inspection costs, (6) time tested Ney alloys for reliability, (7) will withstand extremes in operating environments.

SEND FOR LITERATURE

NEY

The J. M. Ney Company

P.O. Box 990, Dept. F, Hartford 1, Conn.

For more information circle **96** on inquiry card.

wherever random disturbances perturb a control system or exists in any process whatsoever, there exists an application for the statistical computer.

"Two of these areas that the GPS Instrument Company engineering department has gained first-hand experience in are:

1. The study and statistical analysis of Fire Control and Automatic Flight Systems which increased optimalization of performance under limited control surface fluctuation.

2. The distribution of characteristics of a production system consisting of components which independently vary in a random fashion.

"Other areas of application that remain to be exploited are in chemical processing where radomnicity may be the rule rather than the exception in such things as compound structure or blending quality, or, in the business field with its huge complex of statistical phenomena. The GPS Instrument Company is presently planning to initiate action in these fields, and is hopeful that the people engaged in these activities do recognize the value of the analog computer in statistical calculations."

We gather that Mr. Giser agrees there is a place for his computer.

* * *

We also received the following letter which some time ago we wouldn't have even bothered to print; there just wasn't a chance of finding a qualified man willing to go East. But with the aviation industry somewhat soft in spots and more people acquiring computer experience daily, we can hope Mr. Osofsky gets his man.

"We are seeking some experienced analog computer engineers preferably with graduate training in applied mathematics or physics to fill several senior level positions in our Analog Computer Section. . . . Interested people should write to me at Republic Aviation Corporation."

A. J. Osofsky
Supervisor, Analog Computing Section
Republic Aviation Corporation
Farmingdale, Long Island, New York

* * *

Seems the Eastern Simulation Council idea of Study Groups is catching on. At the May meeting of the Western SC Steering Committee it was suggested that study groups might be the answer to the increasing size—and attendant decreasing informality—of the regular WSC sessions. And now we have a letter from *Jerry Kennedy* (EAI, Mount Pleasant, Illinois) saying that they plan the same kind of action in the Midwestern SC.

Computer Events

Denver Research Institute

Dates: 24-25 July 1958
Place: University of Denver, Denver, Colorado
Subject: Fifth Annual Symposium on Computers and Data Processing
The symposium will emphasize Formalized Analysis Techniques, Systems Organization, Logical Design Techniques, Automatic Programming, Components and Devices, Digital Communications.

Association Internationale pour le Calcul Analogique

Dates: 1-7 September 1958
Place: Strasbourg, France
Subject: "Journees Internationales de Calcul Analogique"
An exhibit of analog equipment will open 30 August and continue until 10 September.

Midwestern Simulation Council

Date: 8 September 1958 (tentative
Place: Caterpillar Tractor Company, Peoria, Illinois
Subject: "Land Vehicle Simulation" (tentative)

Central Simulation Council

Date: 8 September 1958
Place: Midwest Research Institute, Kansas City 10, Mo.
Subject: The Digital Differential Analyzer

National Electronics Conference

Dates: October 13-15, 1958
Place: Chicago, Ill.

National Simulation Conference

Dates: 23-25 October 1958
Place: Statler-Hilton Hotel, Dallas, Tex.
The conference will be sponsored by the IRE PGEC and the Dallas Section of the IRE. For further information write J. E. Howard, 2100 Menefee Drive, Arlington, Texas.

Eastern Joint Computer Conference

Dates: December 3-5, 1958
Place: Philadelphia, Penna.

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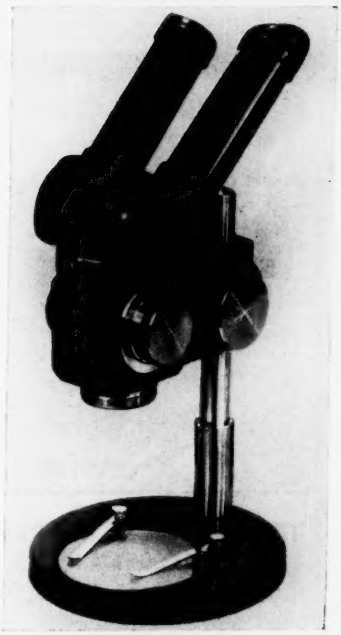

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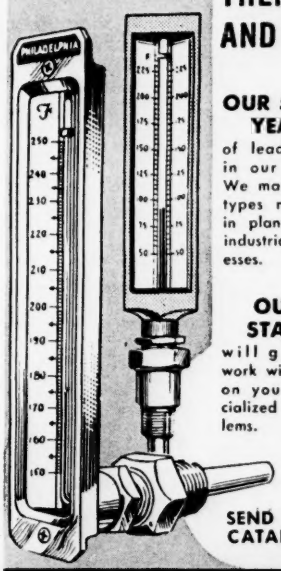

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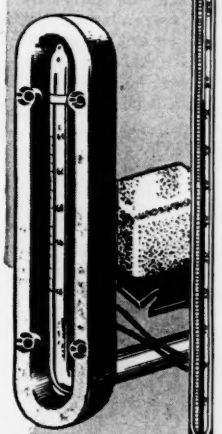

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new instruments

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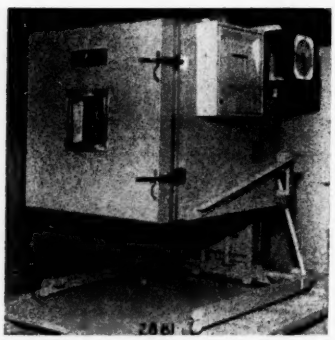
environmental testing

TRANSPORTABLE ENVIRONMENTAL CHAMBERS

New transportable chambers greatly facilitate controlled temperature environmental testing with vibration machines; are available in any workspace size up to 5x5x5 ft; can be moved easily by a permanently-attached specially-designed fort lift. Lifts are electrically or manually controlled and can be adjusted to heights to fit vibrators rated up to a 2,500-lb force.—*Tenney Engineering, Inc.*, 1090 *Springfield Road, Union, N. J.*



For more information circle **213** on inquiry card.

COMBINATION TEMPERATURE AND VIBRATION TESTERS

New series of high-low temperature test chambers are compatible with latest high-force hydraulically-powered Wyle Hydrashaker as well as with conventional electrodynamic vibrators. Access doors, instrumentation ports, etc., to suit customer requirements. Various sizes. Model EP-125 (illus.) has 5 cu ft test space and temperature range from −100°F to 600°F.—*Mantec, Inc.*, 126 *Maryland St., El Segundo, Calif.*

For more information circle **215** on inquiry card.

SHUT-OFF VALVE FOR ENVIRONMENTAL CHAMBERS

New Bulletin 8264 two-way shut-off direct-acting valve, for cooling applications using liquid CO_2 and requiring constant temperatures, features all-stainless-steel packless construction, only two operating parts, watertight molded coils, Teflon discs for tight shut-off up to 1000 psi. —*Automatic Switch Co., Florham Park, N. J.*

For more information circle **214** on inquiry card.

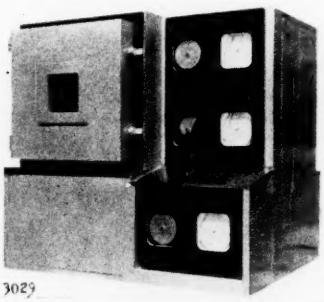
RATE-OF-TURN TABLE ACCESSORIES

New tilt accessory for Model C181 Rate-of-Turn Table enables machine to test and evaluate components on any plane of rotation from horizontal to vertical, permitting complete tests to be made without changing test set-up if table is statically balanced. ★New counterbalanced inclinable mounting stand permits easy positioning of Model C181 Rate-of-Turn Table at any angle up to 90° from horizontal either side of center; adjustable counterweights compensate for weight of test object.—*Genisco, Inc.*, 2233 *Federal Ave., Los Angeles* 64, *Calif.*

For more information circle **216** on inquiry card.

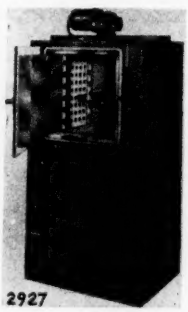
ENVIRONMENTAL TESTER

New 27 cu ft test chamber (3 ft cube cabinet) has standard ranges of −100°F to 200°F, 20% to 95% RH, and 100,000 ft altitude. (Other sizes and ranges available.)—*Environmental Co.*, 369 *Linden St., Brooklyn* 27, *N. Y.*



For more information circle **217** on inquiry card.

OVEN FOR AGING TESTS

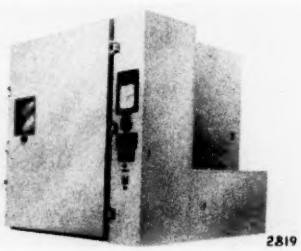


New mechanically convected oven for accelerated aging tests (per ASTM specs D-573 and D-6) has rotating sample holder of aluminum so positioned that samples being tested can be suspended from it and rotated with holder at about 1 rpm. Temperature range 35°C to 180°C, controlled within 0.5 C°; heaters about 2400 watts on 110/220 vac.—*Electric Hotpack Co., Inc.*, 5065 *Cottman St., Philadelphia* 35, *Pa.*

For more information circle **218** on inquiry card.

SALT SPRAY FOG CHAMBERS

New Walk in Rooms operate according to MIL-E-5272-A, etc., come up to operating temperature in one

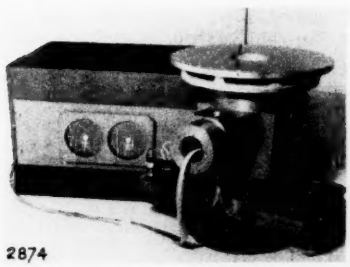


hour and show temperature variations of no more than 0.5 F°; are available in either assembled units (illus.) or prefabricated panels, are ready for immediate operation upon connection of utilities.—*Development Engineering Co., Inc., 9 Cross St., Norwalk, Conn.*

For more information circle **219** on inquiry card.

SERVO TURNTABLE

New T-806E Test Stand, for use where limited tests do not justify cost of a complete turntable testing



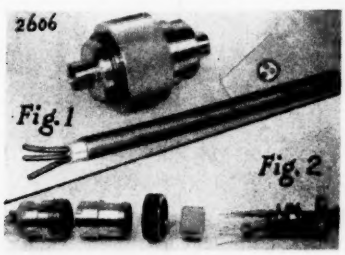
2874

assembly, comprises turntable and trunnion with servo drive, quick-reading dials and two-speed rotation-transmitting system. Mounting can be vertical or trunnioned for tilting.—*Sterling Precision Corp., Instrument Div., 17 Matinecock Ave., Port Washington, L. I., N. Y.*

For more information circle **220** on inquiry card.

EXTREME ENVIRONMENT CONNECTORS

New special-application connectors are for use at high temperature, altitude and radiation. Fig. 1 shows non-polarizing connector for three-#8AWG-wire metal-jacketed and mineral-insulated cable, of special value when necessary to connect and disconnect large-conductor-size metal-jacketed cable frequently and quickly.



★ Fig. 2 shows module package (#16AWG) for extreme environmental conditions of 1000°F temperature and 100,000-ft altitude. Square-sided case permits single-conductor units to be stacked in multiple layers and bound together as a single package. Corona within case is controlled by two close-fitting sleeves for high altitude and extreme atmospheric conditions.—*AMP, Inc., Harrisburg, Pa.*

For more information circle **221** on inquiry card.

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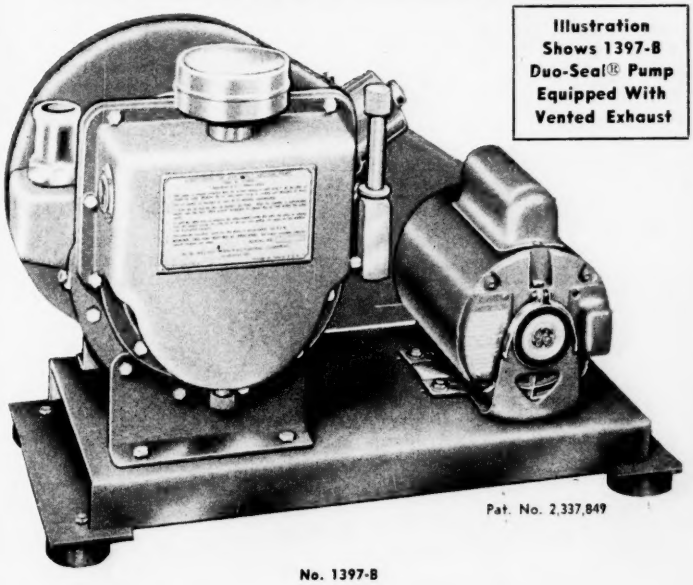

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process analyzers, monitors, controllers

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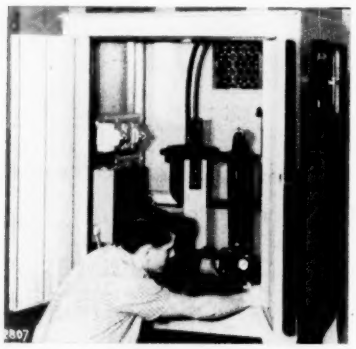


dirty exit gases up to 3200°F for oxygen and combustibles content; is completely enclosed in one cabinet. —*Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.*

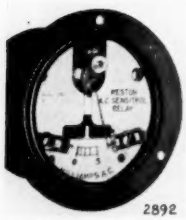
For more information circle **222** on inquiry card.

OXYGEN PURITY RECORDER

New Oxygen Purity Recorder samples output of satisfying columns in liquid or gaseous state; essentially measures argon impurity—the only impurity present in the product from oxygen columns operating with purities above 99%. Recorder chart range is 99%-100%.—*Thermo Laboratories, Johnson Rd., Michigan City, Ind.*

For more information circle **223** on inquiry card.

CONTACT-MAKING INSTRUMENT



New Model 1094 AC Sensitrol Relay employs a moving-iron mechanism (no need for rectifiers or external converters); deflects in proportion to true rms value (surpassing rectifier types which respond to average values and are affected by wave-form errors and temperature effects); is available with either one or two preset contacts and in current or voltage ranges; normally adjusted for 25-125 cps but available also for either 400 or 800 cps. Voltage ranges from 6 to 300 and current ranges from 3 ma to 5 amp.—*Western Instruments, Newark 12, N. J.*

For more information circle **224** on inquiry card.

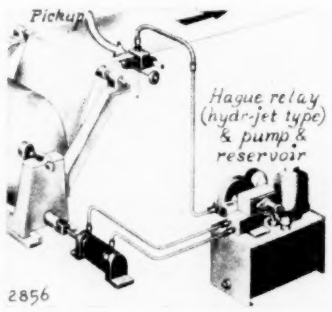
COULOMETRIC ANALYZER

New easy-to-use coulometric analyzer for quantitative analysis is essentially a titration equipment in which end-point is reached by using a measured quantity (coulombs) of electricity instead of a measured quantity of standard chemical. Results are read in digital form, as microequivalents of sample. End point is detected as in ordinary titration, with color indicator, redox potential, pH measurement, etc. Superior accuracy derives from electronic regulator for current supply which holds current within 0.05% for line voltage variations of 107 to 127 vac, thus supplying quantities of electricity known to within limits not previously available in a commercial coulometer.—*Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.*

For more information circle **225** on inquiry card.

WEB GUIDE CONTROL

New Web Guide Control utilizes non-contact method of edge detection, and completely sealed and pressurized

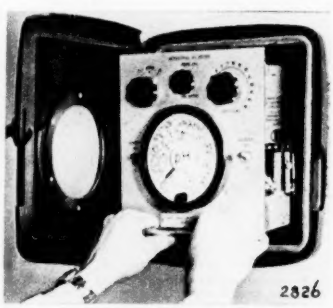


hydraulic power circuit (50 to 750 psi) which permits installing relay in any position or location with respect to hydraulic pump and reservoir.—*The North American Mfg. Co., 4455 E. 71st St., Cleveland 5, Ohio.*

For more information circle **226** on inquiry card.

pH MEASURING EQUIPMENT

New Model 28A industrial pH meter incorporates Isopotential Control System which provides fully automatic temperature compensation for

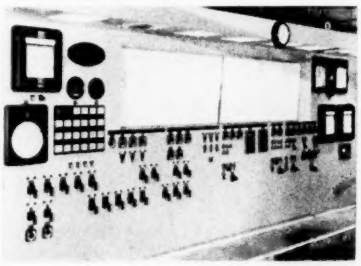


both change of slope and zero shift of pH-millivolt curve—not merely for change of slope as in conventional instruments. Thus, 28A can be standardized in buffer at ambient temperature, irrespective of test-stream temperature. Circuit and feedback system provide stability of 0.02 pH per 24-hour period.—*E. I. L. Instruments, P. O. Box 801, Philadelphia 5, Pa.*

For more information circle **227** on inquiry card.

WATER TREATMENT SYSTEMS

New improved water treatment systems feature innovations such as factory-adjusted control panels

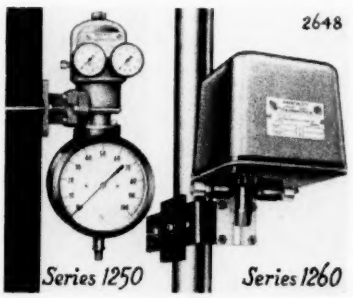


shipped ready for installation and with graphic sections drawn on glass cloth for ease of making changes corresponding to future changes in system. Besides equipment made by company, various makes of instruments are selected for optimal results.—*Illinois Water Treatment Co., Rockford, Ill.*

For more information circle **228** on inquiry card.

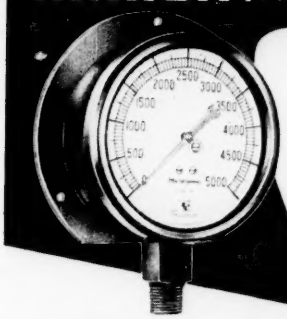
PRESSURE AND TEMPERATURE PNEUMATIC TRANSMITTERS

New Series 1250 Solid Front Ashcroft Pneumatic Pressure Transmitter incorporates Maxisafe Duragauge for



measuring pressures up to 100,000 psi with 0.5% accuracy; utilizes motion-balance principle and its output is 3-15 or 3-27 psi signal proportional to input pressure. ★ New Series 1260 Non-Indicating Ashcroft Pneumatic Pressure Transmitter comes in standard ranges of 0 to 100" water and 0 to 20,000 psi; has 0.5% accuracy and 0.1% sensitivity. ★New Series 1253 is basically like 1250 series, but with bellows element for measuring low pressures, from 0 to 20" water. ★ New Series 3800-

MARSH *Mastergauge*



The gauge that has everything!

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- **STURDY "MARSHALLOY" CASE** . . . formed of boiler-plate-thickness steel, copper clad inside and outside to give it the corrosion resistance of solid copper. It's one third lighter, but four times stronger than cast iron.
- **PRECISION "MASTERGAUGE" MOVEMENT** . . . with such exclusive features as the coined sector gear.
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Marsh Instrument and Valve Co. (Canada) Ltd. 8407 103rd St., Edmonton, Alberta.
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas.

For more information circle **67** on inquiry card.

New miniature SCREW COVER THERMOCOUPLE HEAD

Readily adapted to small diameter protection wells from ⅛" to ¼" dia. with a ⅛" NPT male connector. Also available with ¼" and ⅜" IPS female thread.

Weighs only 3 oz.

For MgO insulated high temperature sheathed thermocouples

For single and duplex elements

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Waterproof cover insures watertight connection

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729 NORTH ADDISON AVE. • VILLA PARK, ILL.

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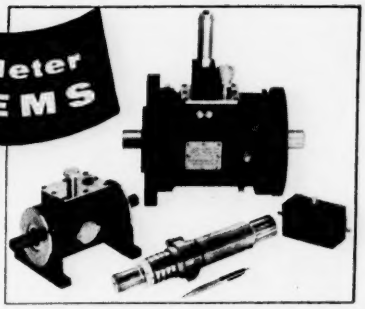

B & F offers the only complete line of Torquometers and Indicators with individual models designed to satisfy specific industrial Torque measuring requirements. Principal of operation is basic, easily incorporated into rugged housings capable of continuous high speed industrial applications. Quality high-signal transducers provide accurate linear readings with negligible hysteresis in high speed and variable temperature operations.

Standard models cover ranges from 0.5 in. oz. full scale through 30,000 in. lb. full scale. Torquometers are available with foot mounted housings and AND-type housings with splined shaft-ends for use on pump test stands and for testing engine accessories. These models are designed to mate with and support pumps, generators, starters, etc. and can be air-purged and pressurized for use in hazardous atmospheres.

NEW miniature Models "D" and "E" cover the in. oz. and low in. lb. ranges required to evaluate servo motors and other low inertia systems.

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STRAIN GAUGE CONTROL UNITS, ACCELEROMETERS

For more information circle **69** on inquiry card.

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Another Important New Technical Advance

Model T-681

Transistorized Relay

SENSITIVE—5 microamperes control 1500 watt load
MINIATURIZED—case dimensions only 3" x 4" x 5"
LIGHTWEIGHT—weighs just 30 oz.
SHOCK AND VIBRATION RESISTANT—no tubes to jar loose
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CAN BE USED IN ANY POSITION—on bench or wall

The PRINCO Model T-681 Supersensitive Transistorized Relay offers exceptional advantages when used with Thermoregulators, Thermostats or other control instruments. It operates on 110-120 volts AC power, provides an activating current of 5 microamperes through the sensing element, and controls a load up to 1500 watts. Two pilot lights indicate position of the contacts and an internal switch provides for reversing from contacts normally closed to contacts normally open. An outlet for controlled load and a convenience outlet for stirrer or auxiliary heater are provided.

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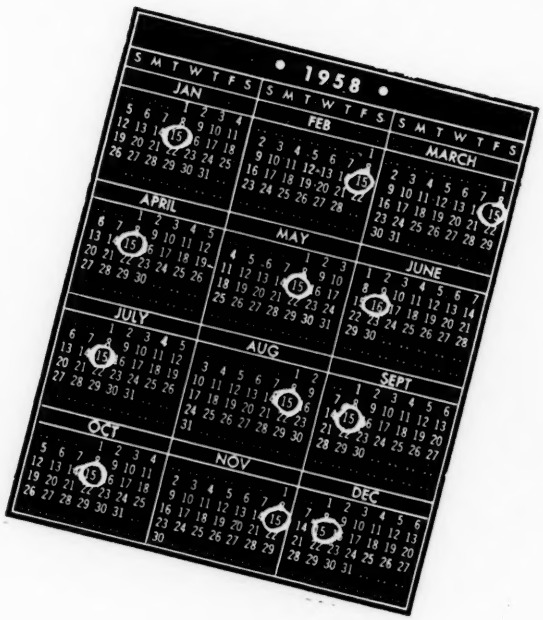

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NEW INSTRUMENTS

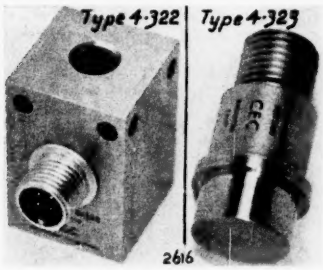
3900 Ashcroft Solid Front Pneumatic Temperature Transmitter comprises American mercury-actuated dial thermometer, and a transmitting unit whose output is an air pressure directly proportional to temperature indication.—*Manning, Maxwell & Moore, Inc., Stratford, Conn.*

For more information circle **229** on inquiry card.

pressure and vacuum

PRESSURE PICKUPS

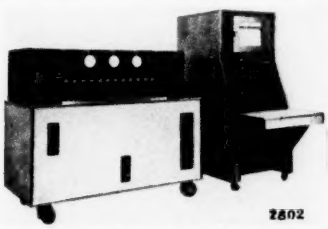
New Type 4-322 Differential Pressure Pickup combines unusually rugged design with sensitive performance; has 4-active-arm unbonded strain-gage sensing element encased in a stainless steel cube; will operate within specs on line pressures up to 350 psi while measuring pressures in ranges of ±7.5, ±12.5, ±25, and ±50 psid. ★ New Type 4-323, particularly suited to rocket and engine test stand applications, operates without damage at temperatures from −300 F to 300 F; provides a nominal output of 40 mv; is available in ranges from 7.5 to 5,000 psig or psia without configuration changes of any kind.—*Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.*



For more information circle **230** on inquiry card.

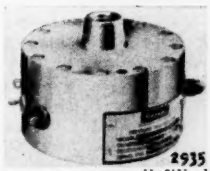
PRESSURE PICKUP CALIBRATOR

New Autocal automatically performs calibration of one to 12 pressure pickups in 2 minutes or less per pickup; yields quantitative data on linearity, sensitivity factor, hysteresis and drift. Calibration is dynamic—not stepwise. Data are presented graphically on an *X-Y* recorder, and digitally by counters. Ease of operation and accuracy maximize calibration efficiency with fewer personnel, and minimize delays.—*Allegany Instrument Co., Inc., 1091 Willis Mountain, Cumberland, Md.*



For more information circle **231** on inquiry card.

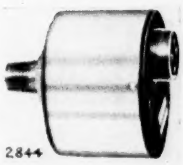
PRESSURE PICKUPS



New Series 46155 Bourdon-tube-element pressure pickups for non-corrosive gas or liquid pressure measurement are oil-filled and withstand 25-G vibration to 2000 cps. Ranges 0-100 to 0-6000 psid or psig and 0-100 to 0-1000 psia. Special-alloy Bourdon tubes minimize temperature error between −55°C and 149°C.—*G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.*

For more information circle **232** on inquiry card.

PRESSURE PICKUP

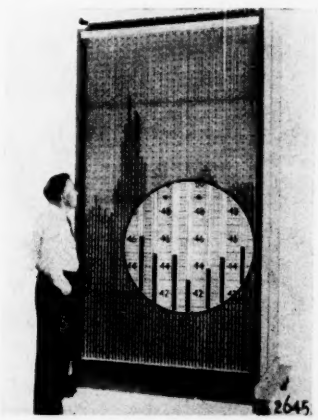


New 70-2107, newest addition to maker's Compu-Tran line, covers range from 30" Hg vacuum to 50" Hg pressure; is designed for automotive and aircraft engine testing. Output 0-50 mv; wear life >3,000,000 cycles.—*International Resistance Co., Computer Components Div., 401 N. Broad St., Philadelphia 8, Pa.*

For more information circle **233** on inquiry card.

PHOTO-MANOMETER

New Photo-Manometer comprises fifty well-type manometers with 100" tubes and individual adjustable wells; is designed for photographing readings where measured phenomena change rapidly. Cabinet has doors at



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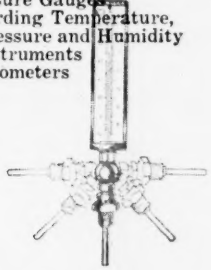
Recording Temperature, Pressure and Humidity Instruments
Hydrometers



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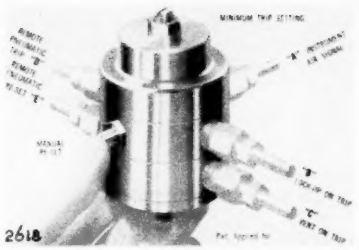
For more information circle **71** on inquiry card.

sides; rolls on rubber-tired casters; has four leveling jacks.—*King Engineering Corp., Box 670, Ann Arbor, Mich.*

For more information circle **234** on inquiry card.

PRESSURE-SIGNAL MONITORS

New Mite-73 trips when a pneumatic instrument signal violates its minimum or maximum setting; remains tripped after signal is restored to normal until manually reset, either locally or remotely. When in service it will relay input signal A to either one or both ports B and C. (Either B or C must be plugged if not required.) Standard max pressure



range 250 psi; minimum trip adjustable 1-100 psi. ★ Mite 70V vents on trip; is reset manually; can be converted to Mite 70L in field. ★ Mite 70L locks up on trip; if reset manually; can be converted to Mite 70V in field.—*George W. Dahl Co., Inc., 86 Tupelo St., Bristol, R. I.*

For more information circle **235** on inquiry card.

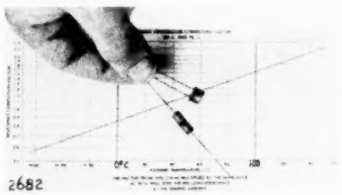
THERMOCOUPLE ASSEMBLIES

New line of industrial thermocouple assemblies comprises standard wire-type and Ceramo TC's, connection heads, thermowells, fittings, and mounting attachments. Combinations of these components provide an extremely wide variety of heavy-duty assemblies.—*Thermo Electric Co., Inc., Saddle Brook, N. J.*

For more information circle **240** on inquiry card.

THERMOMETRIC RESISTOR

New Sensistor, with 0.7%/C° positive temperature coefficient of resistance, features stable, retraceable



characteristic curve. Two models: (1) TM¼ axial-lead molded unit linearly derated at full load from 100°C to 150°C. (2) TC⅛, encased in a TO-5 round-welded package, is derated linearly at full load from 125°C to 200°C. Both units are immediately available in standard resistance ratings from 100 to 1,000 ohms at 25°C.—*Texas Instruments, Inc., P. O. Box 312, Dallas, Texas.*

For more information circle **241** on inquiry card.

temperature

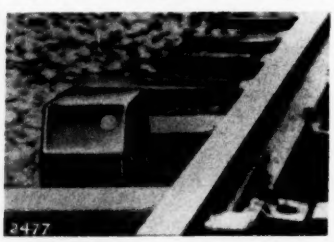
THERMOREGULATOR

New direct-setting Ultra Micro thermo-regulator utilizes displacement principle of ultramicro-buret. Micrometer screw accurately measures position of stainless-steel plunger displacing mercury, and operates a digital counter which displays set-point temperature. Counter covers 100 C° in 0.02 C° divisions. Range (any 100-C° span between −35°C and 200°C) is determined by a secondary larger plunger. Among other features: gold plating of all immersible stainless-steel parts; easy assembly and filling with mercury, as well as easy replacement of glass spiral.—*Emil Greiner Co., 20-26 N. Moore St., New York 13, N.Y.*

For more information circle **236** on inquiry card.

HOT BOX DETECTOR

New Servosafe Hot Box Detective, for use in railroad operations, detects every overheated journal that passes

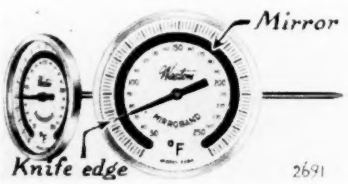


it by measuring infrared radiant flux emitted by journal; transmits data to a chart recorder in a signal tower or other manned location up to four miles from detector.—*Servo Corp. of America, 2020 Jericho Turnpike, New Hyde Park, Long Island, N. Y.*

For more information circle **237** on inquiry card.

TESTING THERMOMETER

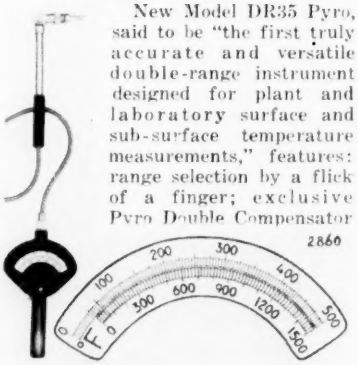
New Model 2284 Mirroband permits, through elimination of parallax errors, more accurate readings than



previously possible in a bimetallic thermometer. Except for glass, unit is encased in welded stainless steel for resistance to most common acids and gases. Head (2" dia) has a scale length of 4½"; standard stem is 8" long. Available in six F and C ranges.—*Weston Instruments, Newark 12, N. J.*

For more information circle **238** on inquiry card.

SURFACE PYROMETER

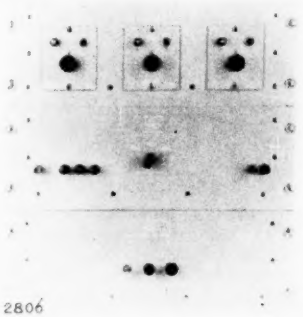


New Model DR35 Pyro, said to be "the first truly accurate and versatile double-range instrument designed for plant and laboratory surface and sub-surface temperature measurements," features: range selection by a flick of a finger; exclusive Pyro Double Compensator for changes in room temperature on both scales; 1.5% accuracy; choice of 15 interchangeable couples and of extension arms.—*The Pyrometer Instrument Co., Inc., Bergenfield, N. J.*

For more information circle **239** on inquiry card.

TEMPERATURE LIMIT CONTROL SYSTEM

New Model TLC-3297 warning and control system, originally designed for nuclear reactors, has three major components: limit-control chassis with plug-in controllers, magnetic alarm amplifier, and power supply. Modular construction permits easy



expansion to 100 channels or more. Primary element of each channel is a resistance coil. Response time <0.8 sec.—*Arnoux Corp., 11924 W. Washington Blvd., Los Angeles 66, Calif.*

For more information circle **242** on inquiry card.

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For more information circle **72** on inquiry card.

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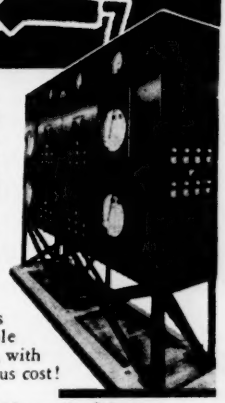

Last (and perhaps least) of the thousands of components in this $20,000 control apparatus are the dozen or so small nameplates and legend plates on the unit. Yet the equipment can not finally be delivered without them. And delay could keep a plant idle.

To insure a ready supply of nameplates, the Automatic Temperature Control Co. of Philadelphia adopted a simple, low-cost way to make them in its own plant, when needed.

This progressive manufacturer makes its own nameplates on a portable ENGRAVOGRAPH (size of a typewriter), with unskilled labor, at a fraction of previous cost!

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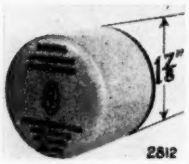
For more information circle **74** on inquiry card.

For more information circle **75** on inquiry card.

acceleration, displacement

ACCELERATION PICKUP

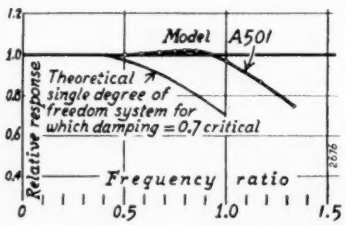


New miniature Model 605 features air-damped spring-mass system which reduces transverse acceleration error to less than resolution at 50 *G*. Standard damping 0.65 critical; 0.1 to 1.0 can be provided. Low-range units can measure acceleration increments of as little as 0.005 *G*.—*Bourns Laboratories, Inc., P. O. Box* 2112, *Riverside, Calif.*

For more information circle **243** on inquiry card.

ACCELERATION PICKUP

New Model A501 embodies a new concept in design of unbonded-strain-gage acceleration pickups: utilization of gas damping, permitting operation



of device over a wide temperature range without addition of a heater jacket. It is offered in ranges from ±5 to ±50 *G*. Its small size (3" L) and its response characteristics make it suitable for use in missiles and aircraft.—*Statham Instruments, Inc.*, 12401 *W. Olympic Blvd., Los Angeles* 64, *Calif.*

For more information circle **244** on inquiry card.

DISPLACEMENT PICKUP

New T833 Transducer for precise measurement of both linear and angular displacements is a differential

transformer type pickup comprising an E-core stator and one or more companion rotors. Sensitivity 0.1 ma per 0.001"/ma excitation at 400 cps.—*Sterling Precision Corp., Instrument Div.*, 17 *Matinecock Ave., Port Washington, L.I., N.Y.*

For more information circle **245** on inquiry card.

DISPLACEMENT PICKUP WITH SELF-ALIGNING SHAFT

New Model 156 Align-O-Pot enables measurement of linear displacement even where perfect alignment with an actuating member is impossible; has vibration error less than resolution at 15 G for travels of 2½" or less and at 25 G for travels from 2½" to 4". Available in travels from ½" to 6½".—*Bourns Laboratories, Inc., P. O. Box* 2112, *Riverside, Calif.*

For more information circle **246** on inquiry card.

flow-rate and volume

INDICATING FLOWMETER

New Mighty-I measures flow in either direction in any pipe from 1½" to 8" without additional components; is installed in minutes in any line. Designed primarily for swimming-pool filter operation; suitable for other services with flow ranges up to 10 to 1. It indicates by means of a ball float. Available with flow-rate scales from 3-30 gpm to 200-2000 gpm.—*Fischer & Porter Co.*, 677 *Jacksonville Rd., Hatboro, Pa.*

For more information circle **247** on inquiry card.

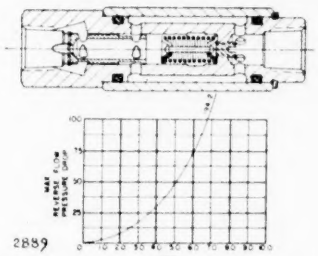
FLOW SWITCHES

New Peeco Flow Actuated Electrical Switches open or close electric circuits at predetermined flow rates of gases or liquids; stop or start pumps, etc.; are made in brass, bronze, steel or stainless steel, to fit lines from ¼" to unlimited size; various switching arrangements and ratings.—*Power Engineering & Equipment Co., Inc.*, 1826 *W.* 213*th St., Torrance, Calif.*

For more information circle **248** on inquiry card.

FLOW REGULATOR

New 194-2-0-1 Regulator is the first to incorporate a free reverse flow check, for use as a pressure-compen-



sated constant-flow regulator in oil hydraulic circuits in which reverse flow of a larger volume than the regulated flow must be obtained at a low pressure drop. Reverse flow is uncontrolled. Example is shown graphically.—*Waterman Engineering Co.*, 725 *Custer Ave., Evanston, Ill.*

For more information circle **249** on inquiry card.

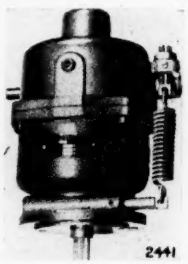
speed

SEVEN-RANGE RATEMETER

New Model DM4 Linear Counting-Rate Meter features seven instantly-selectable full-scale counting ranges from 200 to 200,000 counts per minute, each of which can be accurately calibrated by means of built-in range controls. Front panel controls are also provided for 60-cps calibration. Three time constants: 3, 10 and 30 sec. Output feeds a cathode-follower type integrator, whence direct voltage (proportional to pulse rate) measured on a VTVM calibrated in cpm. A negative output signal is available for operation of other counting equipment; also provision for operation of a 1-ma or a 10-mv recorder.—*BJ Electronics, Borg-Warner Corp.*, 3300 *Newport Blvd., Santa Ana, Calif.*

For more information circle **250** on inquiry card.

GOVERNOR

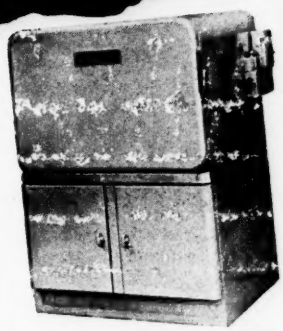


New Type 2300 flyball-type governor, for extremely accurate speed regulation, will find application on diesel and gasoline engines and on steam turbines; also for marine use and where service conditions require a variable-speed governor. Torque capacity 30 pound-inches at 1200 rpm. Constant speed range 500-2400 rpm; variable speed range 500-1440 rpm.—*Farris Pickering Governor Co., Inc.*, 705 *Commercial Ave., Palisades Park, N. J.*

For more information circle **251** on inquiry card.

immediate delivery!

Bemco has many types of chambers available for immediate delivery from stock on a rental or purchase basis. WRITE FOR THE NEW FORTY-FIVE PAGE ENVIRONMENTAL EQUIPMENT MANUAL.



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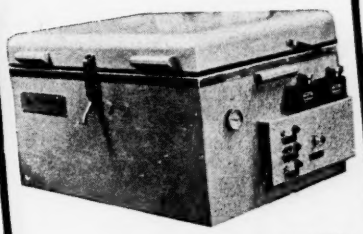
SALT SPRAY CHAMBERS
9 and 30 cubic foot sizes.



WIDE RANGE TEMPERATURE CHAMBER
Model DF-100/650-1 dry ice cooled, electric heat, —100° F. to +650° F.
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ENVIRONMENTAL TEST EQUIPMENT DESIGN AND MANUFACTURE

For more information circle **76** on inquiry card.

GAUGES

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For more information circle **77** on inquiry card.

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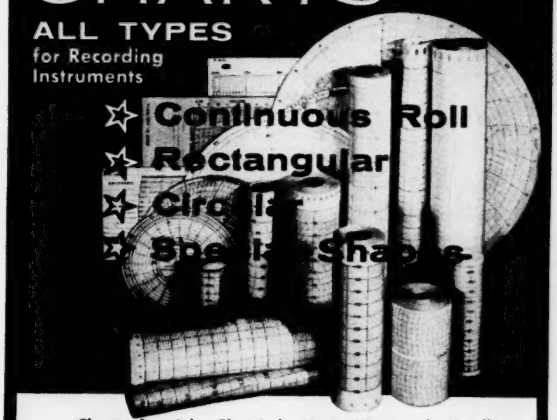

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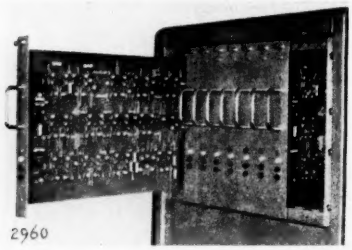
computing and data processing

EXTREMELY HIGH-SPEED DIGITAL COMPUTER

New TRICE (Transistorized Real-time Incremental Computer Expandable) completely solid-state computer



combines accuracy and repeatability of a digital computer with speed, flexibility, and ease of programming of an analog computer. It is an incremental computer composed of independent computing elements that operate in parallel. These units are interconnected (programmed) by means of a plugboard in much the same manner as an analog computer. Size of computer depends on size of equation(s) to be solved. Since TRICE operates in parallel, increasing number of its elements does not affect speed of computation. Basic pulse repetition rate 3 Mc, word length 30 bits, whence iteration rate of 100,000 per second.—*Packard-Bell Computer Corp.*, 11766 *W. Pico Blvd., Los Angeles* 64, *Calif.*

For more information circle **252** on inquiry card.

TINY SAMPLING SWITCH

New Ascop Miniplexer is an extremely small rotary time-division multiplexing device which has 60 contact pins for 30 channels of break-before-make operation. It operates under ambients of −55°C to 125°C and withstands 2,000 cps of 25-G vibration.—*Applied Science Corp. of Princeton, P. O. Box* 44, *Princeton, N. J.*

For more information circle **253** on inquiry card.

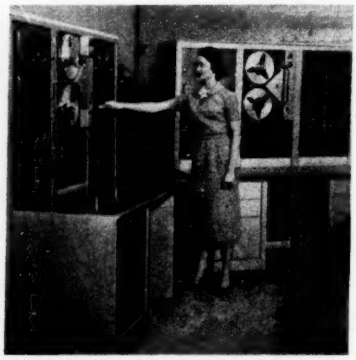
TIME-DATA PRINTER

New Time-Data Printer, for use with maker's Pulse Code Telemetering Receiver, is of parallel-entry type, printing one letter as a key to the type of data, two digits for numerical identification of the transmitted element and three digits and a fraction for actual counting entries. A full reading up to 99' 11⅞" can be recorded. Symbols such as °F, #, etc., can replace fractions when desired. —*The Vapor Recovery Systems Co.*, 2820 *N. Alameda St., Compton, Calif.*

For more information circle **254** on inquiry card.

RAPID DATA-PROCESSOR

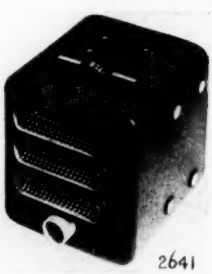
New two-unit DDRT (Digital Data Recorder-Transcriber), using magnetic tape, can handle 100 pieces of



information at once on each of its 100 channels (basic rate of 10,000 samples/sec) in measuring temperature, pressure, strain and other variables. Recorder (left) absorbs data as electrical signals and converts these into digits. Transcriber, an electric playback, reproduces original tape, selects and rearranges predetermined portions into block form for further automatic processing in a computer, and records data blocks on a final tape for direct entry into computer.—*Minneapolis-Honeywell Regulator Co., Davies Labs. Div., Beltsville, Md.*

For more information circle **255** on inquiry card.

SAMPLING SWITCH

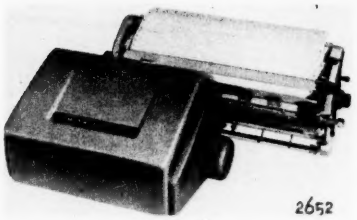


New hermetically-sealed subminiature high-speed sampling switch utilizes a new design concept: drive motor completely contained inside commutating rings, whence a 50% reduction in over-all volume for a given number of circuits. Integral gear box drives 3 poles with 45 bbm contacts at 20 rps. Maintenance-free service under military environmental conditions.—*Instrument Development Labs., Inc., 67 Mechanic St., Attleboro, Mass.*

For more information circle **256** on inquiry card.

DATA PRINTER

New Series MC-203 Data/Log electrically-actuated printing machine is said to introduce a completely new approach to data recording; is completely equipped with its own power supply and control unit so that user needs only supply simple external contact closures: no need to design a



pulse and control circuit. Possible entry of up to fourteen digits simultaneously and record paper width of 18" on an automatically indexed carriage, hence higher rates of data entry, greater reliability and less wear because of fewer number of operations required per data point. —*Monroe Calculating Machine Co., Inc., Electronics Components Div., 60 Main St., San Francisco, Calif.*

For more information circle **257** on inquiry card.

TRANSISTOR LOGIC ELEMENTS

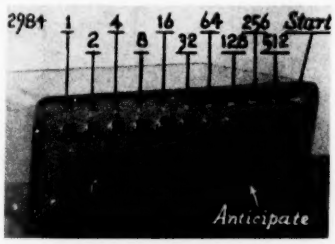
New series of transistor logic circuits and networks, for 100-kc operation and for use from −55°C to 75°C, includes all circuit types required for synthesis of digital systems, including power supplies and clock generators. Both diode and transistor NOR logic circuits are available. All circuits except neon indicators operate from ±18 v and ±6 v, with logic levels of 0 and −6 v.—*Epsco Components*, 108 *Cummington St., Boston, Mass.*

For more information circle **258** on inquiry card.

counting

COUNT CONTROLLER

New Pre-Set Electronic Counter is transistorized; can count at rates up to 100,000 pieces per second; has



automatic overload protection; is designed for 115-v 60 cps operation but performs satisfactorily on line voltages from 70 to 180. Modular design, wherein primary control functions are achieved through proper assembly and interconnection of standard pretested subassemblies, makes it possible to adapt this basic counter for specialized control applications.—*Thias Engineering Associates*, 10617 *Burbank Blvd., N. Hollywood, Calif.*

For more information circle **259** on inquiry card.

photography, etc.

HIGH-SPEED M-P CAMERAS

Two new 16-mm intermittent motion picture cameras are capable of film speeds up to 400 frames per second: DBM III (100-ft film capacity) and DBM IV (200-ft). High resolution and sharpness are obtained by an intermittent movement "of revolutionary new design": film is stopped completely during each exposure and locked in position by register pin.—*D. B. Milliken Co., 131 N. Fifth St., Arcadia, Calif.*

For more information circle **260** on inquiry card.

CAMERA LENSES

New Camex Hyper-Cinor wide-angle and close-up lenses for Camex-Reflex 8-mm single-lens reflex movie camera extend range for continuous focusing from infinity down to 2" for ultra-close-ups and titling without any accessories.—*Karl Heitz, Inc., 480 Lexington Ave., New York 17, N. Y.*

For more information circle **261** on inquiry card.

TELEPHOTO LENS

New fast F/3.5 180-mm Primotar telephoto lens, 7¼" long, interchangeable on all models of 35-mm Exakta cameras, combines high correction and excellent resolving power; closes down to f/22; focuses from infinity to 7.2 ft.—*Exakta Camera Co., 705 Bronx River Rd., Bronxville, N. Y.*

For more information circle **262** on inquiry card.

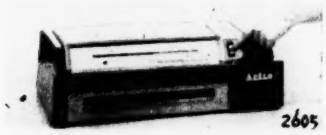
TIMING ALARM DEVICE

New Type 2664 automatic timing alarm mechanism for maker's Polaroid-back Oscilloscope Record Cameras has automatic settings from 30 seconds to two minutes. A special locking device permits repeated automatic resetting at the same time cycle. Device is bell-shaped, made of alloy aluminum, 2⅝" diameter, 1½" deep.—*Allen B. Du Mont Labs., Inc., 750 Bloomfield Ave., Clifton, N. J.*

For more information circle **263** on inquiry card.

PHOTOCOPIER

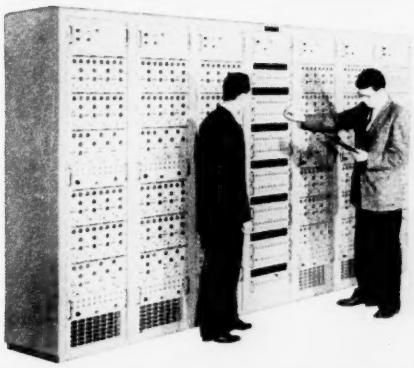
New Uni-matic Auto-Stat, said to be "the fastest photocopy machine in the office equipment field," features



one-step synchronized operation: After paper has been exposed to light source, original is returned while photocopy paper continues through machine to be developed.—*Am. Photocopy Equipment Co., Evanston, Ill.*

For more information circle **264** on inquiry card.

High-Accuracy FM Systems*



**0.15% system accuracy*

Wiancko's packaged FM systems will obtain and store massive amounts of dynamic test data with unmatched precision. This accuracy means less data scatter—better information from each test.

Wiancko systems are economical and easy to operate. Multiplexing, or "packing," various IRIG bands on a single tape track permits the recording of over 144 channels of information on one tape recording head. Packing results in more data with less equipment and a permanent, versatile recording that can be processed by automatic data reduction equipment and be converted to analog form for graphic display. Automatic calibration, zero suppression, adjustable FM oscillators, and "normally thru" input patching provide convenience of operation. Inputs acceptable by Wiancko FM systems include variable voltage, strain gage, variable reluctance, and variable resistance.

Adaptable to a great many applications and requirements, Wiancko FM systems are a ready-made answer to ground-based telemetering problems. Systems can be packaged, using the Wiancko "building block module" principle, to meet practically any specification.

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For more information circle **78** on inquiry card.

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Front Surface Mirrors, Cold Mirrors, Achromatic Beam Splitters, Dichroic Beam Splitters, Monochromatic Interference Filters, Wedge Interference Filters, Heat-Reflecting Interference Filters, Cut-Off Filters, Anti-Reflection Coatings, Heat Protective Coatings and many other thin layers.

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Balzers means research in high vacuum process

For more information circle **79** on inquiry card.

shop equipment and supplies

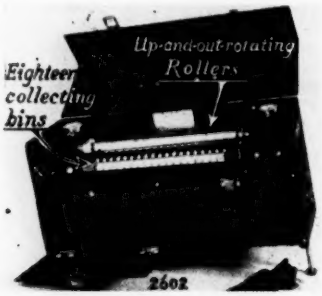
COMBINATION TUBE BENDERS

New combination tube benders bend both hard and soft tubing; handle from 2 to 7 sizes from ¼" to ⅜" OD; make bends up to 180°; are adapted for bending various tubing sizes by changing forming wheel and shoe.—*The Imperial Brass Mfg. Co.*, 6300 *W. Howard St., Chicago* 31, *Ill.*

For more information circle **265** on inquiry card.

MICROMETRIC SORTER

New Roller Mike measures and sorts up to 10,000 miniature pieces per hour with total tolerances down



to 30 microinches. When difference between roller ends is set at 0.001", sorting into groups by 50-microinch increments can be achieved.—*Affiliated Manufacturers, Inc.*, 60 *E. 42nd St., New York* 17, *N. Y.*

For more information circle **266** on inquiry card.

TOROIDAL COIL WINDER

New RW-P high-precision toroidal coil winding machine (made by Micafil Ltd, Switzerland) will wind per-

fect layers to a finished ID of 0.25" to 4" depending on core height; is the only available two-shuttle type toroidal winder that can wind copper wire as small as #45 AWG successfully down to 0.25" finished ID; comes with three standard interchangeable winding heads, core holder for continuous winding over 360°, sector holder for angles up to 330°, unreeling mechanism with adjustable wire tensioning.—*Cosa Corp.*, 405 *Lexington Ave., New York* 17, *N. Y.*

For more information circle **267** on inquiry card.

COMPUTER BOBBIN CORES

New bobbin cores for computer, counter and control circuits feature rigidly-controlled 4-79 molybdenum Permalloy tape; ceramic or stainless steel bobbins; hydrogen-atmosphere annealing; and polyester tape, polyethylene or Nylon protective jackets; are 100% tested to customer performance specs.—*Dynacor, Inc.*, 10431 *Metropolitan Ave., Kensington, Md.*

For more information circle **268** on inquiry card.

METALS COMPARATOR

New non-destructive comparator can be used to test ferrous and nonferrous metals for composition, heat treatment, hardness, case depth, plating thickness, and other properties. It is basically an impedance comparator, indicating changes in metal's chemical and physical properties correlated with electrical and magnetic properties. Small parts, or pieces with equal cross-sectional areas, are usually tested by insertion in a test coil. A test head placed against metal being measured is used on surfaces of large parts.—*Sunshine Scientific Instrument*, 1810 *Grant Ave., Philadelphia* 15, *Pa.*

For more information circle **269** on inquiry card.

LEAK DETECTORS

New Types H-2, H-3, H-4 and H-5 halogen-type leak detectors (four detector heads with one standard control unit) replace long-established Type H-1; can locate leaks as small as 10^{-6} cc/sec in any closed system or component, under pressure or vacuum using any halogen compound gas introduced as a tracer into practically any system that does not already contain a halogen gas. Standard control unit is portable and self-contained with a multi-range indicator. A loudspeaker sounds an audible alarm when indicator exceeds a preset value. Types H-2 and H-5 are designed for manual leak-checking of closed systems and devices containing a tracer gas under pressure. Gun type H-2 has an indicator mounted in gun itself. Light-weight H-5 features a pencil-sized probe. H-3 has a stationary detector for automatic high speed leak checking of parts moving past detector on a conveyor; can also be used for area or system monitoring. H-4, designed for detecting leaks in vacuum systems, is suitable for many applications which formerly required use of mass-spectrometer type.—*General Electric Co., Schenectady* 5, *N. Y.*

For more information circle **270** on inquiry card.

inspection & gaging

SCRATCH MICROSCOPE

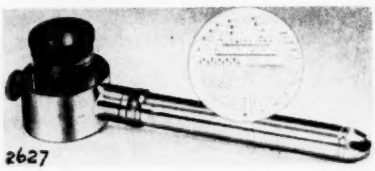
New Hilger & Watts Scratch Investigation Microscope measures scratches up to 0.025" deep on flat or

curved surfaces, to an average of 0.001"; employs a new optical taper sectioning method that gives positive data on scratch conditions where only estimates were possible previously.—*Engis Equipment Co.*, 431 *S. Dearborn St., Chicago* 5, *Ill.*

For more information circle **271** on inquiry card.

ILLUMINATED COMPARATOR

New 6-power pocket comparator with illuminator has etched glass reticle graduated in inches and milli-

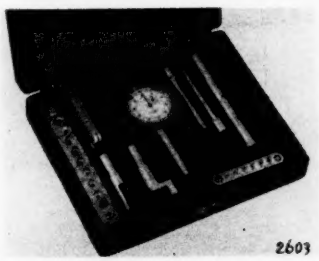


meters; measures diameters, radii and angles. Battery-powered light illuminates both reticle and work.—*Edmund Scientific Co., Barrington, N. J.*

For more information circle **272** on inquiry card.

DIAL COMPARATOR SET

New Set No. 99 combines (1) a dial indicator reading to 0.0001" which accommodates all No. 99 acces-



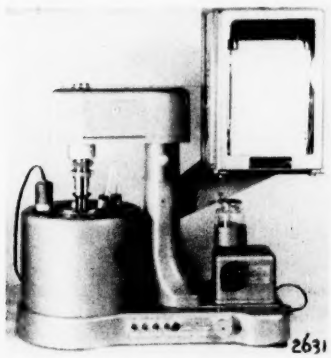
sories; (2) a bore gage with range of 0.200" to 5.090"; a universally adaptable dial test indicator with 0.0005" graduations, 0.075" range, 180° swiveling contact point and up to 6" measuring depth with extensions.—*Alina Corp.*, 122 *E. 2nd St., Mineola, L. I., N. Y.*

For more information circle **273** on inquiry card.

mechanical testing

VISCOSITY TESTER

New Corn Industries Viscometer for accurately measuring and recording consistency of starch pastes

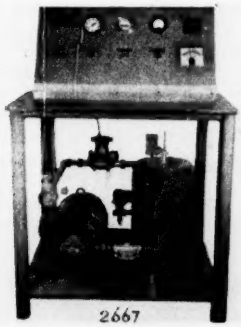


(adopted as standard for starch industry by Corn Industries Foundation) enables quality control tests to be completed at a rate of about 3 an hour, with results repeatable to 1%. ★ Gelometer Attachment uses embedded-disk method.—*Gaertner Scientific Corp.*, 1201 *Wrightwood Ave., Chicago* 14, *Ill.*

For more information circle **274** on inquiry card.

HYDRAULIC-FLUID TESTER

New Hydraulic Fluid Test (Pump Method) facilitates evaluation of all petroleum, synthetics, and water-base



fluids under fixed conditions of pressure, temperature and time. Equipment includes 2-hp electric motor, Vickers pump, Neptune meter, 50-mesh SS filter, 3½-gal reservoir with thermostatted water-jacket, pressure gage, thermometer, solenoid valve, relief valve, etc.—*Research Appliance Co., P.O. Box* 307, *Allison Park, Pa.*

For more information circle **275** on inquiry card.

BALL BEARING TESTER

New SmoothRator determines performance qualities of precision-grade oil-lubricated instrument ball bearings by vibration analysis at average hourly rate of 60 to 100; can be set

For more information circle **80** on inquiry card.

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Electrical Differential Drives are part of the family of SPECON variable speed drives and differential transmissions designed and produced by Stratos. They utilize a motor-generator combination electrically coupled in a closed loop and mechanically coupled to a double differential gear box.
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For more information circle **81** on inquiry card.

"We taught ourselves to use the Bendix G-15 computer ...it's that easy."

PETER M. LANG, *Senior Engineer*
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"Our nuclear engineering staff, in developing commercial power reactors, required a full-sized digital computer that the entire group could use. We picked the G-15 and I was first to learn its use. I taught myself in two days without help and in turn taught two-day classes for other ACF employees. Many of us had no previous computer experience, but we are now keeping our G-15 'hopping'—often seven days a week and eight to twelve hours a day."

THE G-15 GIVES YOU memory and speed of computers costing four times as much • Typewriter input-output, paper tape output and 250 characters/sec paper tape input at no added cost • Punch card input-output available • Extensive library of programs furnished • Strong user's sharing organization • Proven reliability • Nationwide sales and service • Lease or purchase.

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For more information circle **82** on inquiry card.

NEW INSTRUMENTS

up in 10 to 15 minutes, including calibration. No interpretation by operator is needed; results are read directly in units related to limits established by bearing user.—*The Barden Corp., Danbury, Conn.*

For more information circle **276** on inquiry card.

electrical testing

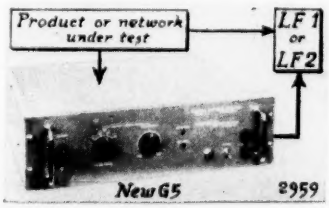
DOUBLE-PULSE GENERATOR

New Model B3-3 provides two pulses of identical amplitude and polarity from a single pulse-forming unit; can be used as a double-pulse generator (with both pulses timed with respect to a sync pulse or with second pulse timed with respect to the first) or as a single-pulse generator. Single pulses can be generated at rates up to 1 Mc and pulse pairs at rates up to 500 kc. Each pulse width is variable from 0.08 usec to 10,000 usec. Repetition rate of internal oscillator is from 10 cps to 1 Mc or instrument can be triggered externally.—*Rutherford Electronics Co., 8944 Lindblade St., Culver City, Calif.*

For more information circle **277** on inquiry card.

RESPONSE TRACING SYSTEM

New Model G5 subsonic response indicator, used in conjunction with maker's Subsonic Spectrum Analyzer



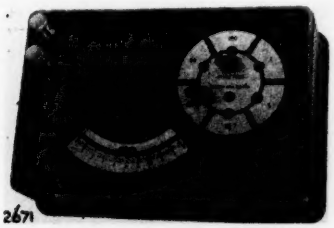
(Model LF-1 or LF-2), analyzes frequency response characteristics of servo amplifiers, filters, acoustic reproducers, transformers, shaker tables, etc., in low-frequency range from 0.5 to 2250 cps, within which automatic linear excursions of 20, 100, or 500 cps can be centered at any point.—*Panoramic Radio Products, Inc., 520 S. Fulton Ave., Mt. Vernon, N. Y.*

For more information circle **278** on inquiry card.

electrical and electronic instruments

HEAVY-CURRENT DC AMMETER

New direct-reading dc ammeter is the first with full-scale ranges from 1 to 100 amp and 0.2% accuracy to



be available in self-contained form: without external shunts and leads. —*Sensitive Research Instrument Co., 310 Main St., New Rochelle, N. Y.*

For more information circle **279** on inquiry card.

PANEL INSTRUMENTS

New Crown Series is designed to satisfy need for functional beauty without sacrificing accuracy, readability or ease of mounting; is said to afford greater readability than ever before achieved, with excellent illumination from top, front, and sides of case. Lower portion of case is prismatic surface (available custom-colored). Maker's Cormag mechanisms obviate need for external shielding. Scales are 2½" long in a 100° arc.—*Weston Instruments, Newark 12, N. J.*

For more information circle **280** on inquiry card.

AC VTVM

New WV-74A high-sensitivity ac vacuum-tube voltmeter measures ac voltages from 0.01 to 100 and decibels from −40 to +40; is useful also as a wide-range audio preamplifier, having about 38 db maximum gain. Frequency range on all measurement and amplifier functions is from 20 cps to 500 kc.—*Radio Corp. of Am., 30 Rockefeller Plaza, New York 20, N. Y.*

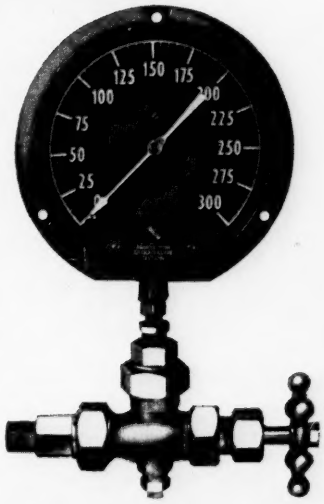
For more information circle **281** on inquiry card.

OSCILLOSCOPE

New Model 85-A, designed for teletype and allied operational systems, features superior LF sweep linear-

PENBERTHY

INSTRUMENT VALVE



Specially designed for and successfully used in instrument and regulating piping. Without dismantling piping network, dial gage replacement or repairs can be made. Back-seating stem permits repacking while valve is under pressure. Quality standards of complete line of Penberthy gages and valves maintained. Well worth investigating.

FORGED CARBON STEEL
STAINLESS STEEL TRIM
BACK-SEATING STEM
RENEWABLE SEAT
INTEGRAL PRESSURE BLEED
available in variety of materials and connections.

WRITE *for detailed information Dept. A*

PENBERTHY MFG. CO. 1242 Holden Ave., Detroit, Mich.
DIVISION OF BUFFALO-ECLIPSE CORPORATION

For more information circle **63** on inquiry card.

NOW HIGH PRECISION CONTROL ACCURACIES for TESTING PRODUCTION LINE ITEMS
from −70°C. *to* +320°C.

Example of standard test tray to test semiconductors.

MODEL TC-5

check these **CONTROL ACCURACIES**

LIQUID CO_2	±½°C. −70°C. to +320°C. Model TC-5B	DRY ICE	±½°C. −55°C. to +320°C. Model TC-5
	± 1°C. −70°C. to +175°C. Model TC-2B		± 1°C. −55°C. to +175°C. Model TC-2A
	± 2°C. −70°C. to +320°C. Model TC-4B		± 2°C. −55°C. to +320°C. Model TC-4

OTHER IMPORTANT FEATURES
★ Convenience of operation through interchangeability of test trays.
★ Savings in design evaluation time and in lowered production costs.
★ Liquid CO_2 refrigerant allows lower temperature operations for extended periods of time.
★ Fast heat-up time—from 10 minutes.
★ Low cost—compared to other makes.

With the addition of the Model TC-5 to the line of Statham Development's Environmental Test Chambers, closer control tolerances (to ±½°C.) can be achieved to meet any production and laboratory testing need. The new proportioning electronic heat controller provides accurate temperature control and indication. The test trays used in all Statham Test Chambers are interchangeable for greater convenience and elimination of loading delays. If trays for special applications are required, Statham's engineers will provide test tray fixtures to meet your requirements.

Write today for technical data on how Statham's Environmental Test Chambers will meet your precision control accuracy requirements.
Prices range from $550.00 to $1100.00

Statham DEVELOPMENT CORPORATION
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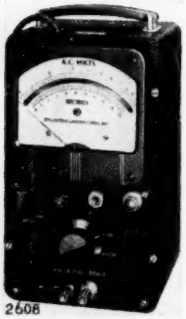
For more information circle **84** on inquiry card.

ization and high-gain balanced-input dc amplifiers; meets MIL-O-15525D (with greatly improved capabilities in LF Spectrum).—*James S. Spivey, Inc., 4908 Hampden Lane, Washington 14, D. C.*

For more information circle **285** on inquiry card.

ELECTRONIC VOLTMETER

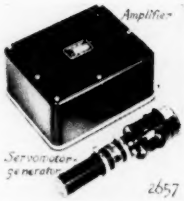


New general-purpose lab Model 300-D has maintained its 2% accuracy without recalibration and tube replacement over several thousand hours of use; essentially comprises a high-impedance attenuator followed by a feedback-stabilized amplifier which feeds an average-responding rectifier-meter circuit. Voltage ranges 0.01/0.1/1/10/100/1000 v full-scale; frequency range 10 cps to 250 kc.—*Ballantine Labs., Boonton, N. J.*

For more information circle **286** on inquiry card.

amplifiers

SERVO AMPLIFIER

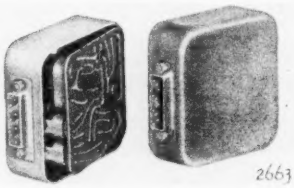


New Type AMP-9616 transistorized −55° C to 125° C servo amplifier features variable damping or feedback control and a wide range of input impedances. Input can be arranged in a summing configuration for use as a differential amplifier. Output power up to 10 watts. Open-loop power gain up to 90 db. Available with or without integral power supply.—*John Oster Mfg. Co., Avionic Div., 1 Main St., Racine, Wis.*

For more information circle **287** on inquiry card.

TRANSISTOR AMPLIFIER

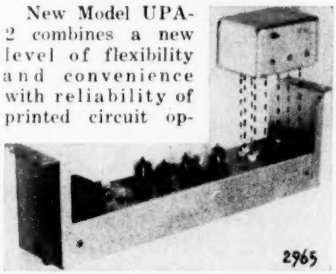
New Series 101 Silicon Transistor Amplifier weighs less than 5 oz; comprises a voltage and current amplifier followed by a phase discriminator stage. Input signal can be either a square wave or sine wave. Power requirement 115 v @ 400 cps; power gain can be externally controlled from 50 to 75 db. Two versions: Model 101A delivers 500 mw of phase-sensitive dc into a 3-terminal center-tapped load; Model 101B delivers 500 mw of phase-sensitive ac across a 3-terminal load.—*Precision, Inc., 730 Lyndale Ave., North, Minneapolis, Minn.*



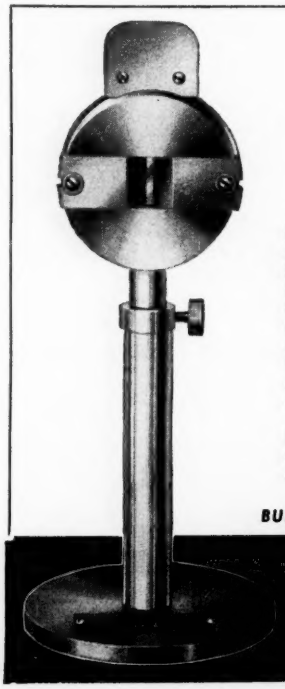
For more information circle **288** on inquiry card.

PACKAGED AMPLIFIER

New Model UPA-2 combines a new level of flexibility and convenience with reliability of printed circuit operational amplifiers; can drive a 12,000-ohm load to 100 v in either direction, and will tolerate large values of cable capacitance. It is an "operational" amplifier; user can select the desired operation and, within limits, the performance level.—*George A. Philbrick Researches, Inc., 230 Congress St., Boston, Mass.*



For more information circle **289** on inquiry card.



EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

*Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

THE EPPLEY LABORATORY, INC.

SCIENTIFIC INSTRUMENTS

NEWPORT, RHODE ISLAND, U. S. A.

For more information circle **85** on inquiry card.

power supplies

WIDE-RANGE POWER SUPPLIES

New Model MR36-15 (0-15 amp) and Model MR36-30 (0-30 amp) Magnetic Rangers are tubeless regulated 5-36 vdc power supplies featuring 0.25% regulation accuracy, 0.2-sec response time, 105-125-vac input, 150-mv ripple, and continuously variable outputs. Rack or cabinet models, fully equipped.—*Sorenson & Co., Inc., Richards Ave., South Norwalk, Conn.*

For more information circle **290** on inquiry card.

TRANSISTORIZED SUPPLIES

New TPC-5 power supplies can be furnished for any desired output between 1 and 25 vdc. Rated output current is 350 ma; 1% regulation over entire input voltage and output current ranges. 120-vac input is reduced through a specially designed SIE transformer, rectified in a bridge circuit and filtered. A portion of output voltage is compared to a Zener diode reference voltage, amplified in a transistor circuit, and applied to input to maintain a constant output voltage.—*Southwestern Industrial Electronics Co., 2831 Post Oak Rd., Houston 19, Texas.*

For more information circle **291** on inquiry card.

PRECISION DC POWER SUPPLY

New Model L3520A, continuously variable from 0 to 350 vdc @ 0 to 200 ma, can be used to do the work of several different models. Regulation 0.1% for 10% line or no-load to full-load; transient response 1 ms; ripple 1 mv. Bias source available at 0-150 v, 0 to 5 ma; also filament source 6.3 vac, CT, 0-10 amp. Line input 105-125 vac @ 50 to 400 cps. Rack or cabinet models; with ammeter and voltmeter as optional features.—*Dept. L, Universal Electronics Co., 1720-22nd St., Santa Monica, Calif.*

For more information circle **292** on inquiry card.

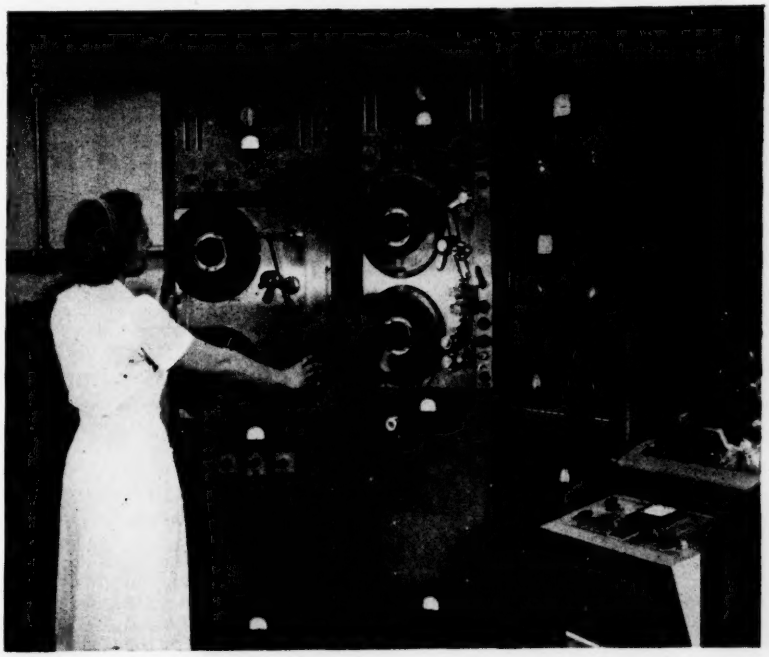
SOLID-STATE POWER SUPPLY

New transistorized power supplies for computer, automation, telemetering, and missile ground-system applications, incorporate 100% hermetically-sealed Grade I Class R transformers and chokes designed to meet MIL-T-27-A. Other reliability features include short-circuit protection, 100% wire-wound MIL-type resistor complement, at least 25% derating of all components, and internal blower cooling. Close regulation is achieved through a stable high-gain balanced amplifier, double-zener-diode reference voltage stabilization, and a new loop design requiring no internal calibration or stability adjustments.—*NJE Corp., 345 Carnegie Ave., Kenilworth, N. J.*

For more information circle **293** on inquiry card.

The world's toughest referee

...a count of one and the tape is OUT!



The machine above is a unique testing instrument, designed by Audio Devices engineers and installed at the Audiotape plant in Glenbrook, Conn. This Automatic Defect Counter records and plays back every inch of the EP Audiotape under test.

Type EP is the extra precision magnetic recording tape for applications in computing, automation, telemetering and seismography. If the tape fails to record a single test pulse out of the millions put on a single reel, the entire reel is rejected. There are no ifs, ands or buts.

This is one of many special quality-control operations to which type EP Audiotape is subjected. The extra attention begins at the raw material stage where the master rolls of base materials are critically examined for uniformity of gauge, freedom from stretch, and cleanliness. The oxide and binder components are selected for fineness of dispersion and magnetic properties—then combined and fed through a micronic filter and metered on the selected foil in Audio's special dust-free precision coating machines. The coated master rolls are then selected for freedom from imperfections and proceed through the slitting operation. Each ribbon is wiped after slitting to remove all traces of dust, run through the defect counter, rejects discarded, and the defect-free tape packed in hermetically sealed metal cans or plastic cases.

The defect counter does its job so well that type EP Audiotape is *guaranteed* to be defect-free! For more information write for free Bulletin T112A. Write Dept. T1, Audio Devices, Inc., 444 Madison Avenue, New York 22, N. Y.

type EXTRA PRECISION EP audiotape TRADE MARK

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444 Madison Ave., N. Y. 22, N. Y.

Export Dept.: 13 East 40th St., N. Y., 16 • Cables "ARLAB" • In Hollywood: 840 N. Fairfax Ave.
In Chicago: 5428 Milwaukee Ave. • Rectifier Division: 620 E. Dyer Rd., Santa Ana, Calif.

For more information circle **86** on inquiry card.

electrical components

"EXPANDABLE" RECTIFIER

New A750 can be combined with inexpensive threaded bushings (also available from maker) to form simple

assemblies for kilowatts of rectified power. Individual unit is sealed and threaded at each end, so it can be screwed into these bushings or into a chassis heat sink or plugged into a clip holder. Each unit is 1" long, inverse voltage rating of 400, and maximum forward current of 750 ma. —*Audio Devices, Inc., 620 E. Dyer Rd., Santa Ana, Calif.*

For more information circle **294** on inquiry card.

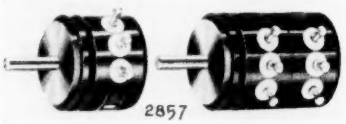
PRECISION VDRs

Four new precision voltage-dividing resistors: New Type 747F is a 2" AIA standard linear unit, available in standard resistance values with 0.25% linearity standard (0.1% special); performance otherwise comparable to 747E. ★ New 2" 10-turn Type 932 offers extremely high accuracy; linearity values of 0.01% in optimum resistance ranges; counterbalanced wiping mechanism and new design techniques for error correction; resistances from 100 to 500,000 ohms. ★ New 5" shaped-card sine-cosine Type 755 features extremely high functional conformity of 0.15% and uniform resolution regardless of angle; can be ganged on special order with 5" linear on non-linear units. ★ New 1⅞" sine-cosine Type 758 is a square-card type utilizing 4 brushes; angular accuracy 0.5°; amplitude accuracy 0.75%.—*Fairchild Controls Corp., Components Div., 225 Park Ave., Hicksville, N. Y.*

For more information circle **295** on inquiry card.

PRECISION VDRs

New precision voltage-dividing resistors with aluminum cases and covers are light in weight, of short



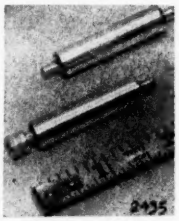
length, have high heat rating, and are made in AIA sizes to close standard resistance and linearity tolerances. Number and location of taps available varies with specific models. All servo mount types are equipped with ball bearings; all bushing mount types have sleeve bearings.—*Osborne Electronic Corp., 712 S. E. Hawthorne Blvd., Portland, Oregon.*

For more information circle **296** on inquiry card.

electronic components

COAX COMPONENTS

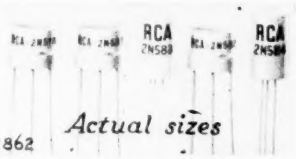
Two new series of rugged microminiature coaxial components: (1) attenuators with a precision of 0.5 db, and (2) impedance matching pads having a low loss. New units are designed for ½-watt input power; mate with EPL microminiature coaxial connectors.—*Electro-Physics Laboratories, 2065 Huntington Drive, San Marino, Calif.*



For more information circle **297** on inquiry card.

TRANSISTORS

Eight new transistors: three of germanium *p-n-p* alloy type, 2N578, 2N579, and 2N580, for high-current

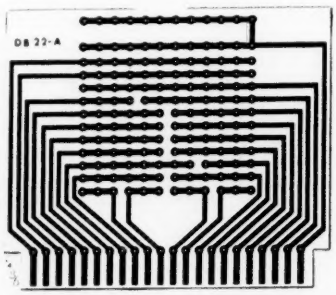


switching circuits of computers and in other on-off control circuits; three of germanium alloy-junction type, 2N581, 2N583, and 2N585, for use in medium-speed switching circuits of military and industrial computers; two junction transistors of germanium *p-n-p* alloy type, 2N582 and 2N584, for use in high-speed switching circuits of electronic computers.—*Semiconductor and Materials Div., Radio Corp. of America, Somerville, N. J.*

For more information circle **298** on inquiry card.

DIODE BOARD

New DB 22A enables computer designers to simplify packaging problems. As many as 48 diode and re-



sistor elements can be mounted on this printed-circuit 22-terminal plug-in board (which can also be used as a non-plug-in unit.)—*Techniques, 52 Jackson Ave., Hackensack, N. J.*

For more information circle **299** on inquiry card.

electromechanical components

DRUM SWITCH

New Bulletin 350 Series B is for starting and reversing small ac and dc motors.—*Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 4, Wis.*

For more information circle **300** on inquiry card.

PUSH BUTTON SWITCHES

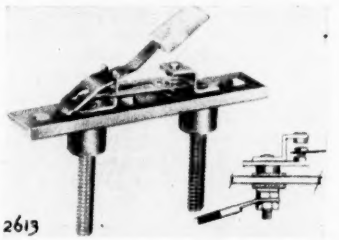
New Button Switches are completely enclosed in metal housing, with red or black push buttons, non-locking;

two designs: 903 for behind panel mounting and 923 for mounting from front; available in single make, single break, single make-break, and make before break. ★ New Tini-Switch 923 is similar to maker's Littel Switch except for miniature design.—*Switchcraft, Inc., 5555 N. Elston Ave., Chicago 30, Ill.*

For more information circle **301** on inquiry card.

SNAP-ACTION SWITCH

New S25-24B offers exceptional flexibility: permits installation on one side of panel and wiring from the



other. Operating force 5 oz max; release force 3 oz max.—*Cherry Electrical Products Corp., 165 Deerfield Rd., Highland Park, Ill.*

For more information circle **302** on inquiry card.

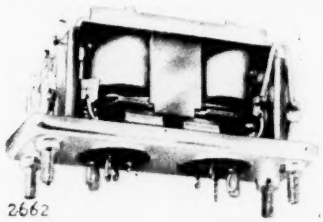
CLUTCH-BRAKE

New miniature No. 3MP, for use in computers, etc., weighs 14¼ oz, is a magnetically-set clutch with a spring-set brake incorporating fail-safe brake; comes complete with drive and driven shafts; can be wound for any dc voltage up to 28. —*Stearns Electric Corp., 120 North Broadway, Milwaukee 2, Wis.*

For more information circle **303** on inquiry card.

SHOCK-RESISTANT RELAY

New KG11DG dual-coil magnetic-latching relay switches loads up to 30 amp @ 30 vdc in applications requir-

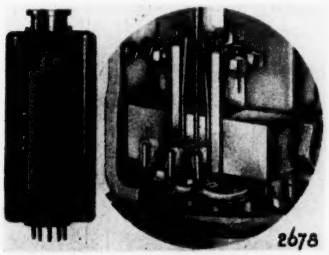


ing resistance to 100-*G* shock and 30-*G* vibration to 2000 cps; can be operated as a polarized relay or from two separate sources (for operate and for reset).—*Potter & Brumfield, Inc., Princeton, Ind.*

For more information circle **304** on inquiry card.

DC-AC CHOPPERS

New miniature dc-ac choppers feature a novel twin-contact arrangement: two independently-adjustable

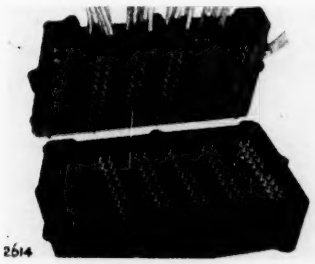


parallel-connected contacts making a total of four for sp-dt and eight for dp-dt. Eleven models, for 50, 60, 94, or 120 cps.—*Stevens-Arnold, Inc., 22 Elkins St., S. Boston, Mass.*

For more information circle **305** on inquiry card.

MULTICONTACT CONNECTOR

New plug-in connector can make or break any number of electrical circuits simultaneously; is self-aligning



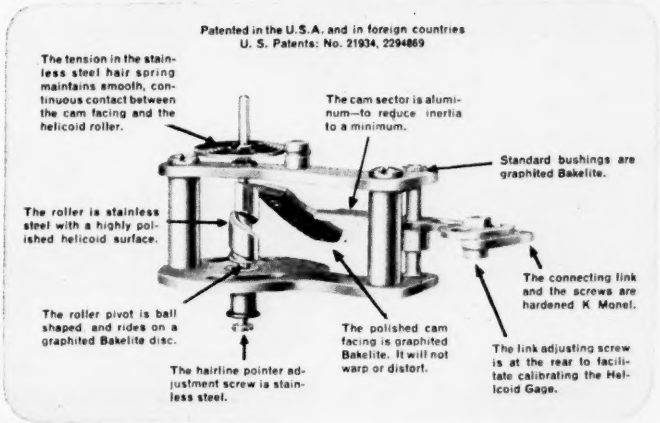
yet makes possible a positive seal of basic terminal arrangement. (First application: ground-to-missile power switching unit of Snark missile.) Virtually any number of connections can be made: 2,200 contacts are made simultaneously in one model.—*Code Electric Co., 8439 Steller Drive, Culver City, Calif.*

For more information circle **306** on inquiry card.

ACCO Helicoid Gage U.S.A.

Nothing but the best in gages for working pressures from 30" vacuum to 10,000 p.s.i.

These details of Helicoid gage design assure longer life and enduring accuracy


Patented in the U.S.A. and in foreign countries
U. S. Patents: No. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is aluminum—to reduce inertia to a minimum.
Standard bushings are graphited Bakelite.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

The superiority of Helicoid Gages is most evident in severe service—wherever a gage is subjected to violent pressure pulsations or severe mechanical vibrations.

The *sustained accuracy* of Helicoid Gages over *millions of cycles* is explained by the details of design and construction of the Helicoid movement shown above. Such Helicoid features—protect against wear and corrosion and assure sensitivity, sustained accuracy and trouble-free operation.

The Chemical Gage

The Helicoid Chemical Gage has a guaranteed accuracy of plus or minus 1%. It is applicable for working pressures from 30" vacuum to 5000 p.s.i. and temperatures to 400° F. It is particularly suitable for chemicals and other viscous fluids which might clog or corrode a Bourdon tube. Pressure and/or vacuum is transmitted directly to the indicating gage element through deflection of a Teflon or Kel F sealing diaphragm.

Tubes built for millions of pressure pulsations

To fit the wide range of applications, Helicoid Bourdon tubes are available in four materials—alloy steel, K Monel, stainless steel and phosphor bronze.

All Helicoid tubes are made from seamless tubing and are carefully designed to give maximum torque and minimum stress. When used within the dial range, they will withstand many millions of pressure pulsations and will not stretch, leak or crack.

For complete information on the Helicoid line of gages write for **Catalog G-52**

Helicoid gives you all these features at prices that are competitive in the quality gage field.

Helicoid Gage Division
AMERICAN CHAIN & CABLE

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ACCO TRADE MARK

For more information circle **87** on inquiry card.

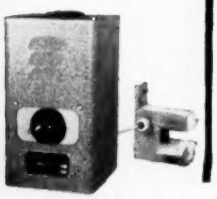
POST DECITRON ELECTRONIC PRODUCTS

Controls & Timers

Model K-1

Model K-1
This is a general purpose photoelectric control whereby the interruption of a light beam closes a relay which, in turn, can be used to activate an external circuit.

Model K-2
The "K-2" control differs from the "K-1" in that the output relay will not energize for each interruption of the light beam, but only if interruptions cease. Useful for detecting stoppage "flow".



Model K-2

Model TA-1 — *Industrial Timer*
. . . a general purpose electronic timer which requires no warmup time and offers good repetitive accuracy. Actuation of the timer is by external contacts, momentary or sustained.

Decitron

POST ELECTRONICS

Division of Post Machinery Co. | 162 Elliott St., Beverly, Mass.

For more information circle **88** on inquiry card.

PRINTED CIRCUITRY
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For more information circle **90** on inquiry card.

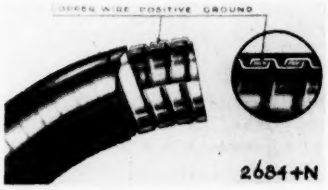
mechanical components

BREADBOARD PARTS

New Standard Electromechanical Breadboard Parts (3-day delivery) include grid plates with mounting surface flat to 0.002"; shaft and component hangers and hanger adapters machined to stand perpendicular (front face to base) ±6 minutes and with bores parallel to within 0.001" TIR; hanger adapters for maker's electromechanical components; and blank adapters for special applications.—*Helipot Corp., Newport Beach, Calif.*

For more information circle **307** on inquiry card.

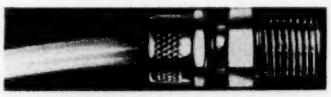
FLEXIBLE CONDUIT



New U. A. Sealflex Black Liquid-Tite synthetic covered flexible conduit is recommended for use where UL approval is specified for complete protection against liquid and moisture vapor conditions. It has extra-heavy galvanized steel core with copper wire positive ground and over-all black polyvinyl chloride plastic cover. Available in ⅜", ½", ¾", 1" and 1¼" electrical conduit trade sizes.—*Universal Metal Hose Co., 2133 S. Kedzie Ave., Chicago 23, Ill.*

For more information circle **308** on inquiry card.

TUBE FITTING

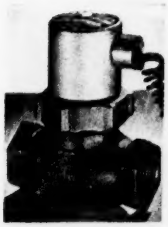


New Swagelok Knurled Nut, for connections on glass and plastic tubing, is especially recommended for installations that are hard to reach. When it is finger-tight, fitting forms a leakproof seal. A wrench pad on knurled nut permits use of wrench if desired. Available from local distributors' stocks in sizes ⅛" to 1" OD tube.—*Crawford Fitting Co., 884 E. 140th St., Cleveland 10, Ohio.*

For more information circle **309** on inquiry card.

valves

SOLENOID VALVES

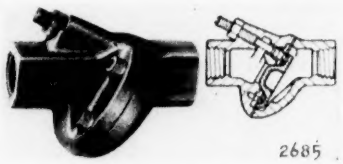


New low-cost Type M packless 2-way piston-pilot-operated valves are said to include as standard equipment many features available in other valves only at extra cost: molded-epoxy waterproof coils, unbreakable piston rings, guided pilot valve seats, etc. Nine sizes from ⅜" to 3", for pressures to 400 psi and temperatures to 340° F. Immediate delivery.—*J. D. Gould Co.*, 4707 *Massachusetts Ave., Indianapolis* 18, *Ind.*

For more information circle **310** on inquiry card.

FLOW CONTROL VALVE

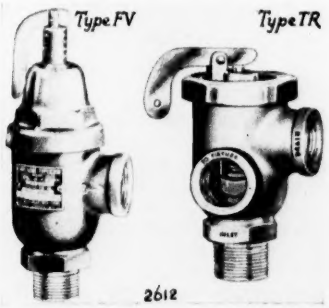
New Micro-Trol, said to permit unusually precise control of air, gas or low-pressure hydraulic flow with unrestricted return, features locked screw adjustment and unique combination of controlling elements, threaded stem and molded Nylon flapper. Available sizes ¼" through ¾" NPT. Flow area through valve is said to exceed nominal rated pipe size.—*Valvair Corp.*, 454 *Morgan Ave., Akron, Ohio.*



For more information circle **311** on inquiry card.

RELIEF VALVES

New Type FV self-closing combination temperature and pressure relief valves for water heaters, etc., incorporate unique design features which qualify their listing, certification and rating by both AGA with hot-water discharge rating and ASME with emergency steam discharge rating. ★ New Type TR tem-



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HIGH FREQUENCY INDUCTION HEATING UNITS

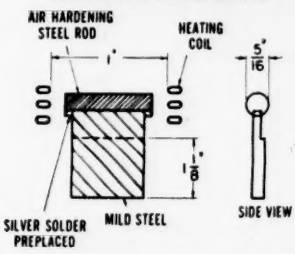
HARDENING BRAZING SOLDERING ANNEALING BOMBARDING MELTING

The Lepel Line of induction heating equipment represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating.

If you are interested in induction heating you are invited to send samples of the work with specifications. Our engineers will process and return the completed job with full data and recommendations without any cost or obligations.

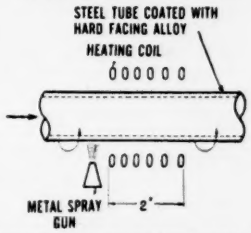
TYPICAL INDUCTION HEATING APPLICATIONS

SIMULTANEOUS HARDENING and BRAZING

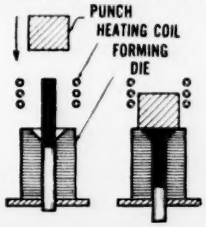


The machined and finished rod of air-hardening steel is simultaneously hardened and brazed to a mild-steel tab. Use of a purified hydrogen atmosphere and a high temperature brazing alloy permits successful hardening of alloy steels without discoloration and scaling even in the absence of flux.

DIFFUSION BONDING OF SPRAYED METAL COATINGS



Corrosion or wear resistant metal coatings sprayed on metal surfaces can be improved by heating to achieve alloying by diffusion. The drawing shows a typical arrangement for processing steel tube sprayed with hard facing alloy. Long tubes may be progressively sprayed and heated.



HEATING HIGH STRENGTH ALLOYS FOR FORMING

Uniform and rapid heating of high strength alloys (alloy steels, titanium, etc.) aids in upsetting and forming operations and also minimizes oxidation and embrittlement.

Electronic Tube Generators from 1 kw to 100 kw.
Spark Gap Converters from 2 kw to 30 kw.

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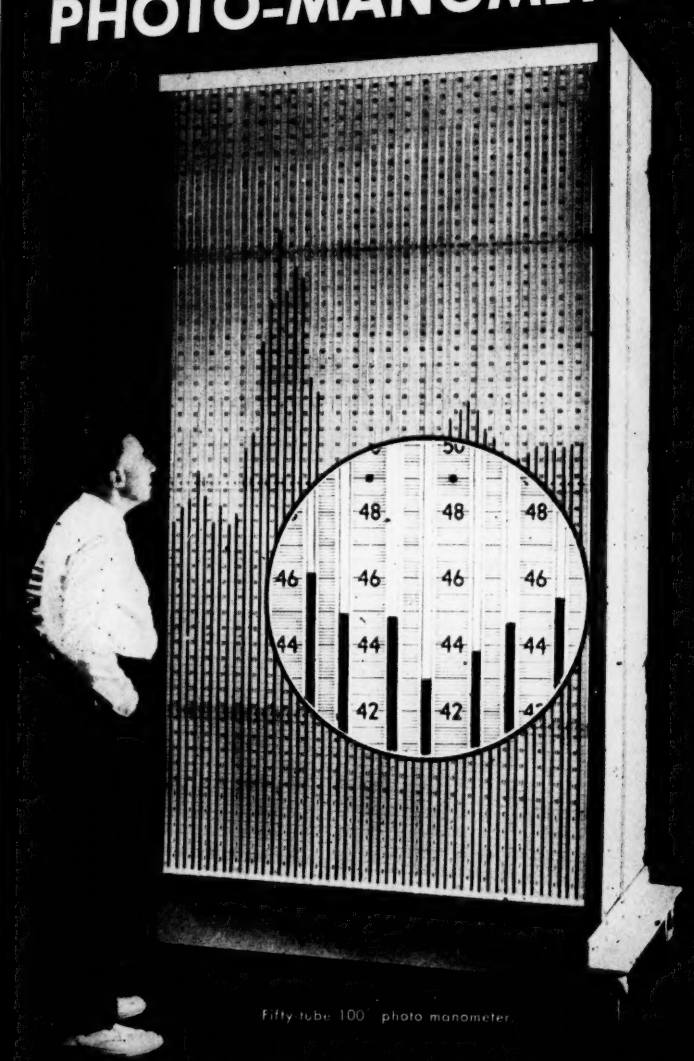
For more information circle **91** on inquiry card.

King PHOTO-MANOMETERS



Fifty tube 100" photo manometer

These multi-tube manometers, with built-in backlighting, are photographed to obtain simultaneous readings and permanent records of measurements. They have 2 to 100 tubes as required, of any length to 170"; individual or common wells, with manual or motorized adjustment. Illustrated BULLETIN 2900 gives details. Write for it.

Catalog on COMPLETE LINE of manometers available on letterhead request

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MANUFACTURERS OF GAUGING EQUIPMENT FOR OVER 30 YEARS

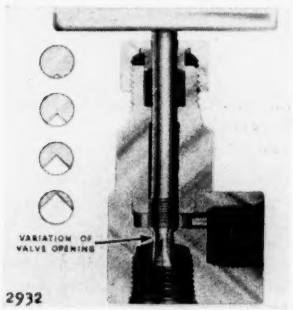
For more information circle **92** on inquiry card.

perature relief valves protect hot water tanks and heaters already protected by a pressure-only relief valve. (Some codes and individual preferences call for two separate valves.)—*A. W. Cash Valve Mfg. Co., Decatur 60, Ill.*

For more information circle **312** on inquiry card.

METERING VALVE

New type of bar stock valve utilizes Veegroo Tapered Orifice principle to eliminate clogging problems. Pressure



ratings 3000 and 10,000 psi. Materials: carbon steel; 303, 316 or 416 stainless steel, Alloy 20; Monel; aluminum.—*General-American Valve Co., P. O. Box 444, Corona del Mar, Calif.*

For more information circle **313** on inquiry card.

LARGE BALL VALVES

New large-capacity balanced ball valves feature zero leakage sealing for liquid nitrogen at 1200 psig and

other difficult fluids. Round-port full-bore sizes from 2" to 24". Illustrated: Model RB-30118-S1 with 16" straight-through flow passage; actuator operates on 120-psig nitrogen or air; position limit switches enclosed in sealed actuator housing.—*The Vickery Co., 610 Sixteenth St., Oakland 12, Calif.*

For more information circle **314** on inquiry card.

TWO-POSITION VALVE

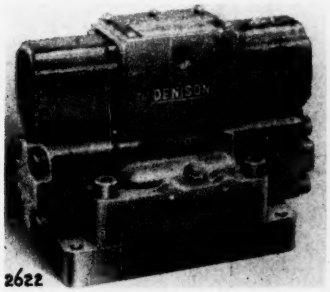
New electropneumatic poppet valve for applications requiring closure on either power or pneumatic failure, and where a minimum operating pres-

sure of 10 psig exists and uniform timing is 5 sec maximum, is smaller and lighter (2 lb) than similar-sized butterfly valves; uses a 400-cps or 26 vdc solenoid. Stationary piston inside movable cylinder minimizes complexity.—*Barber-Colman Co., Rockford, Ill.*

For more information circle **315** on inquiry card.

4-WAY VALVES

New pilot-operated solenoid-controlled 4-way valves meet all JIC requirements; provide all porting and



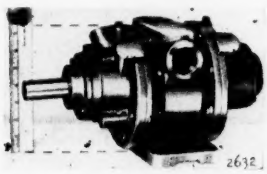
positioning arrangements on circuits up to 3000 psi.—*Denison Engineering Div., American Brake Shoe Co., 1160 Dublin Rd., Columbus 16, Ohio.*

For more information circle **316** on inquiry card.

actuators

ROTARY AIR MOTOR

New 7-hp explosion-proof Model 16AM features compactness, light weight (65 lb), speed infinitely varia-



ble from 300 rpm up with any simple low-cost air valve control. Air supply 30 to 90 psi; delivered hp varies with pressure and speed: 90-psi rating is 5.8 hp at 1500 rpm; 7 hp at 2000 rpm. —*Gast Mfg. Corp., P. O. Box 117, Benton Harbor, Mich.*

For more information circle **317** on inquiry card.

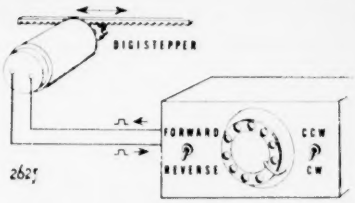
TWO-WAY STEPPER MOTOR

New 8-oz size-15 precision incremental motor rotates an external shaft and connected load through any specified angle up to 36° in response to a pulsed input; accepts consecutive command pulses from either of two independent sources in any order (so that successive shaft steps can be continuously clockwise or counterclockwise, or any random combination of both directions); will drive a load possessing up to 25 gm cm² moment of inertia and/or up to 2 oz-in friction torque; will operate at any altitude and at temperatures from −65°F to 160°F.—*Clary Dynamics, 408 Junipero St., San Gabriel, Calif.*

For more information circle **318** on inquiry card.

STEP-ACTION ACTUATOR

New Model 7105 Digistepper, for digital control of gyros, machine-tool positioning, etc., where overshoot is intolerable, drives mechanisms with-

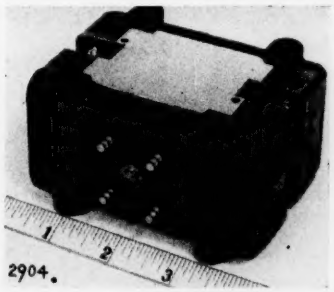


out costly conversion from digital-to-analog servo voltages. Bidirectional digital stepping rates up to 60 steps per second. Typical motor with 180:1 gear head produces 80 oz-in torque for a 1° step.—*The Digitran Co., 45 W. Union St., Pasadena, Calif.*

For more information circle **319** on inquiry card.

TORQUE MOTOR

New Model 106, developed to meet non-military industrial need, outperforms much more expensive units be-



cause it was designed for economic producibility without straining to minimize size and weight. Size 4" x 3¼" x 2¼"; weight 3.4 lb; input power 4 watts; output force ±15 lb at midposition; force sensitivity 3.75 lb per watt input power; stroke sensitivity 0.01 in/watt.—*American Measurement & Control, Inc., 240 Calvary St., Waltham 54, Mass.*

For more information circle **320** on inquiry card.

SPAGHETTI SLEEVING

MADE FROM

TEFLON*

is Carefully Inspected and Controlled Dimensionally!

● PF spaghetti sleeving made from Teflon* is widely used for slip-on insulation, instrument tubing, bundle sheathing, medical tubing, pigtails and similar applications. It slips on easily, in long lengths up to 3 feet, can be used with tinned or bare wire rather than silvered and it wears longer. 25 sizes, 2 wall thicknesses, 10 colors in stock, 100% inspected and controlled dimensionally, are available, all with these important advantages:

- **good dielectric strength (500 to 2000 volts/mil)**
- **lowest dielectric constant (2.0) and dissipation factor (0.0002) of any solid dielectric**
- **no change of electrical properties with temperature (—25°C to +250°C) or frequency (60 cycles to 100 mc)**
- **zero moisture absorption**
- **unaffected by any commercial chemical**
- **stress relieved for negligible shrinkage**
- **continuous service temperature of 250°C—intermittent to 300°C**

Write, wire or call for further details and engineering assistance. Ask, too, for information on PF Teflon* flexible tubing, heavy-walled tubing and rod stock.

PENNSYLVANIA FLUOROCARBON CO., INC.

1115 N. 38th Street, Phila. 4, Pa. EVergreen 6-0603

*Teflon—DuPont trade name for Tetrafluoroethylene resin

For more information circle **93** on inquiry card.

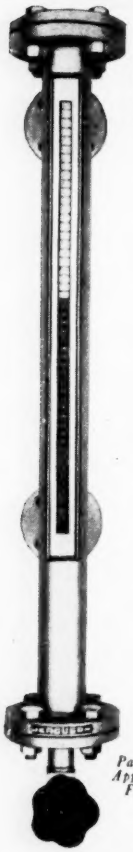
Announcing

the New

Jerguson

MAGNETIC GAGE

For Liquid Levels



An important advancement in liquid level observation for plants with dangerous explosive or inflammable conditions.

Safety design seals against escaping gases.

Measuring mechanism in stainless steel chamber.

Scale mounted outside chamber; magnetically actuated through chamber wall.

Distinct, accurate level shown in red contrasted with silver above.

Job designed, correlating pressure, temperature, and specific gravity.

For pressures up to 2500 lbs. @ 600° F.

Patent Applied For

Can also be used for interface indication.

Write now for engineering sheet on Jerguson Magnetic Gages.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY

100 Adams Street, Burlington, Mass.

Offices in Major Cities

In Canada: Peacock Bros. Ltd.

For more information circle **94** on inquiry card.

time and sequence

AUTOMATIC PULSE TIMER

New Automatic Pulse Timer comprises a unidirectional (rather than bidirectional) Stepper Motor associated with gears, cams, solenoids, switches, an indicator light and—for an independent time base—a stop watch. It can count preselected number of 2 to 60 pulses, having a uniform or variable rate up to 25 pulses per second.—*Stepper Motors Corp., 7444 W. Wilson Ave., Chicago 31, Ill.*

For more information circle **321** on inquiry card.

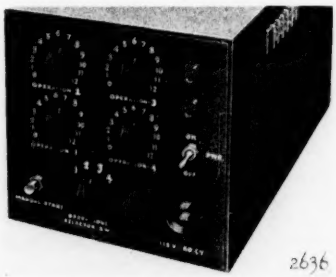
TIME DELAY RELAYS

New time delay relays feature new transistorized circuitry with *RC* network permitting intervals from 50 milliseconds to several hours. Extensive line includes delayed pull-in, delayed drop-out, and pulse types, all with 10% nominal accuracy, wide operating temperature ranges and shock and vibration resistance of MIL-E-005272B, Procedure II extended.—*The Victoreen Instrument Co., Jordan Electronics Div., 3025 W. Mission Rd., Alhambra, Calif.*

For more information circle **322** on inquiry card.

PROGRAM CONTROLLER

New Incremental Position Control is a multi-event sequence controller commanding a plurality of operations



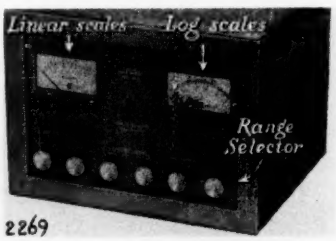
(four in model shown), or operating as a single-function sequence controller commanding resistor or valve increments.—*Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12, Ill.*

For more information circle **323** on inquiry card.

nucleonics

AVERAGING RATEMETER

New extremely-versatile Model RM-7 Rate Meter converts randomly-spaced pulses into an average count



rate per minute. In monitoring applications, it will operate a chart recorder.—*Technical Associates, 140 W. Providencia Ave., Burbank, Calif.*

For more information circle **324** on inquiry card.

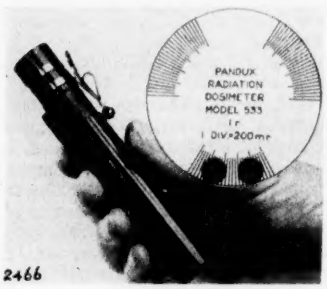
PARTICLE ACCELERATOR

New Model PN-250 Van de Graaff particle accelerator, designed especially for pulsed neutron output in conjunction with subcritical assemblies, reactor design studies and nuclear engineering training, has an energy rating of 0.25 Mev nominal, with ion current during pulse of 50 ma nominal. Pulse length 100 usec; adjustable within 25-250-usec range at option of user. Pulse rise and decay time <5 usec; pulse repetition rate 400 pps nominal and synchronous with alternator supplying ion-source power. Weight 1200 lb.—*High Voltage Engineering Corp., Burlington, Mass.*

For more information circle **325** on inquiry card.

PERSONNEL DOSIMETER

New low-cost pen-type personnel dosimeter comes in various ranges for industrial and professional fields, for

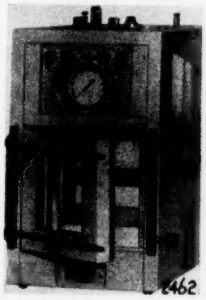


use by the public, by CD workers, etc. Exposure is determined by reading angle between charged spheres. Accumulated exposure can be read, as leakage is less than 0.01% per day. *Pacific Transducer Corp., 11836 W. Pico Blvd., Los Angeles 64, Calif.*

For more information circle **326** on inquiry card.

lab equipment

ANAEROBIC INCUBATORS

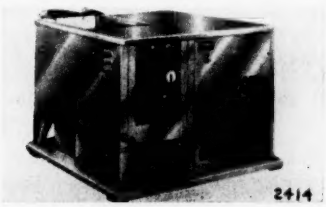


New Models 3640 and 3630 enable aerobes and strict anaerobes to be grown by accurate control of gases, variable pressures and temperatures. Temperature range, room to 65°C; temperature differential, 0.5 C°. CO_2 tension can be accurately established in less than 1 min.—*National Appliance Co., 7634 S. W. Capitol Hwy., Portland, Oregon.*

For more information circle **327** on inquiry card.

REFRIGERATED BATH

New low-cost Magni-Whirl, with new range of 0°C to 100°C, features uniformity and control to 0.25 C°; all

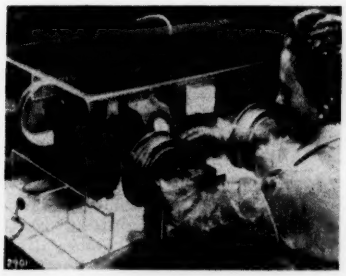


polished stainless steel; no ice, no circulation of cold water; unique magnetic pumping action which provides gentle agitation without motors or stirrers.—*Blue M. Electric Co., 138th & Chatham, Blue Island, Ill.*

For more information circle **328** on inquiry card.

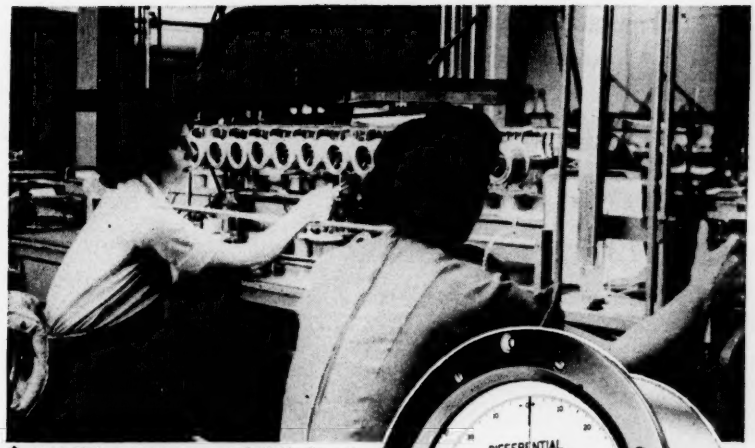
TRANSPARENT HOOD

New transparent plastic dry box with entry ports provides dust-free draft-free work-space for assembling



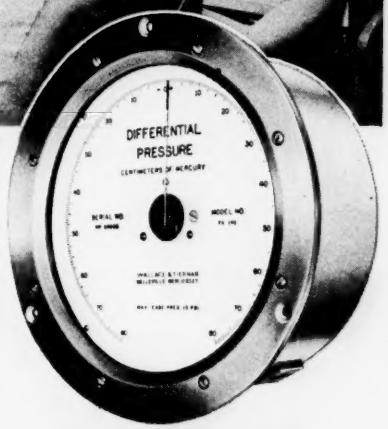
semiconductors or testing precision instruments. Inert gases can be introduced. Standard model has four iris-diaphragm ports permitting cooperation of two workers; sleeves and access door are gas-tight when closed. Ports can be fitted with gas-tight vinyl sleeves up to 20" long.—*Air-Shields, Inc., Hatboro, Pa.*

For more information circle **329** on inquiry card.



▲ W&T 3" low pressure gauges, individually calibrated, are checked against a precision standard.

A 6" gauge for easy readout is also available. ▶



PRESSURE MEASUREMENTS WITH PRECISION

W&T low pressure gauges bring 0.3% accuracy, rugged portability to your job

Calibration checked and double-checked . . . so you know the gauge is right when you record a reading. And W&T pressure gauges stay accurate in spite of rough handling. You can use them right on the job—still have laboratory accuracy.

These gauges are in stock now. For information write Dept. A-122.48

service: gauge pressure; differential pressure; vacuum determinations; or as compound pressure-vacuum gauges with zero center; **accuracy:** 1 part in 300; **sensitivity:** 1 part in 500; **minimum range:** 0 to 10 inches H_2O; **maximum range:** 0 to 400 inches H_2O; intermediate ranges of pressure or vacuum in any pressure equivalent are also available.

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CHLORINATORS and CHEMICAL FEEDERS

for
- **slime elimination**
- **water treatment and purification**
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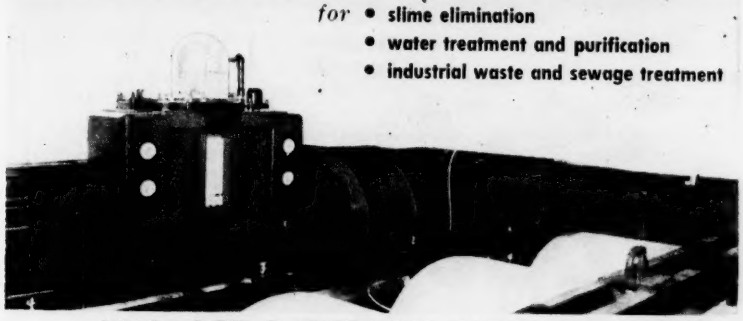

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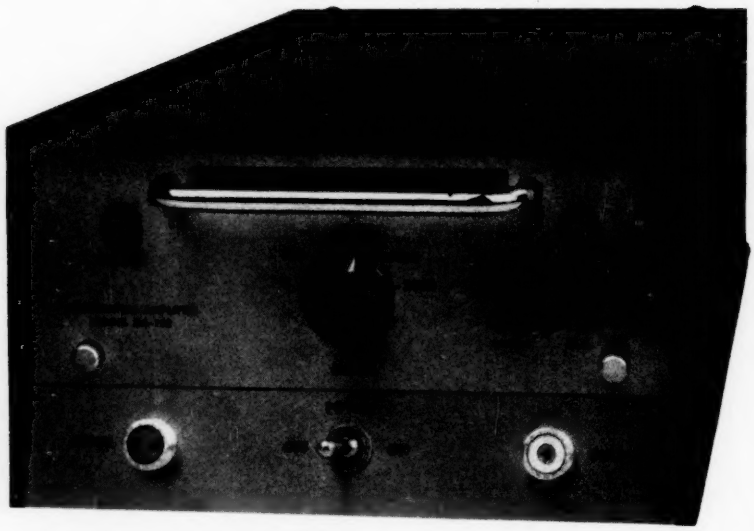
For more information circle **95** on inquiry card.

The amplifier
you have been waiting for...



EPSCO DA-102

WIDE-BAND DIFFERENTIAL

LOW-LEVEL DC AMPLIFIER

Designed for applications involving either dynamic or quasi-static data, the Epsco DA-102 is a wide-band, chopper-stabilized, differential DC Amplifier with very high open-loop gain. The differential input isolates the signal source, minimizing errors due to stray ground currents, hum and pick-up.

Compare these specifications:

6.5μ volts noise at 10 KC • 200,000 to 1 DC common mode rejection • up to 50,000 to 1 AC common mode rejection • less than 2μ volts per day short term drift • 3 db response at 20 KC for a gain of 1000 • 0.1% stability • ±20 volts DC single-ended output • up to 40 ma output current • 0, 100, 200, 500, 1000, 2000 gain settings

Complete specifications on request. Portable and rack mounting models available now for immediate delivery.

EPSCO SYSTEM BUILDING BLOCKS

- low-level differential amplifiers
- high-speed electronic multiplexers
- quick-look oscillograph recorders
- voltage-digital converters
- magnetic core buffer storage units
- transistorized logic circuits

Epsco — First in data control

Epsco, Incorporated, 588 Commonwealth Ave., Boston 15, Mass. For service in the West: Epsco Service Corp. of California, 1722 Westwood Blvd., Los Angeles 24, California

For more information circle **89** on inquiry card.

miscellaneous

CORROSION TESTER

New portable model of Corro-Dex has batteries with at least six months' service life; single knob control; readings indicate corrosion rate directly in microinches; large assortment of available probes: steel, nickel, tin, Monel, aluminum, etc., for pressures up to 4000 psi and 700°F.—*Labline, Inc., 3070 W. Grand Ave., Chicago 22, Ill.*

For more information circle **330** on inquiry card.

HIGH-VACUUM-JACKETED TRANSFER LINES

New vacuum-jacketed lines minimize boil-off losses of low-temperature liquid fuels for rockets and missiles. Because of heat transfer as small as 5.5 to 11 Btu/ft/hr, new transfer lines can show fuel savings up to 50% over conventionally insulated lines. Even greater savings are possible over unjacketed lines. Available in sections up to 40 ft long and in sizes of 1¼" and 3" OD.—*Consolidated Electrodynamics Corp., Rochester Div., 1775 Mt. Read Blvd., Rochester, N. Y.*

For more information circle **331** on inquiry card.

LOW APPROACH INDICATOR

New Model ID-525 features unique rectilinear display design affording improved readability, appearance and performance as well as lighter weight and smaller size; is directly interchangeable, mechanically and electrically, with ID 48.—*Marion Electrical Instrument Co., Grenier Field, Manchester, N. H.*

For more information circle **332** on inquiry card.

GLASS APPARATUS

New industrial and lab glass apparatus and parts include special stopcocks (with or without unique Nester spring attachment), burettes, manifolds or branches, gas collecting tubes, ground and graduated ware. Two broad categories: (1) hand-blown precision apparatus; (2) semi-mechanically produced items such as flanges, rings, goose-necks, etc.—*L. G. Nester Co., Inc., Millville, N. J.*

For more information circle **333** on inquiry card.

COLORIMETER

New Precision ASTM Colorimeter, designed to fully comply with ASTM D1500, considerably improves method for obtaining color values in a wide variety of lubricating and heating oils, diesel fuel oils and petroleum waxes in 16 color standards.—*Precision Scientific Co., 3737 W. Cortland, Chicago, Ill.*

For more information circle **334** on inquiry card.

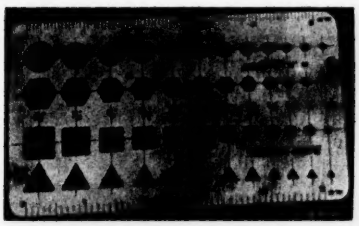
VACUUM ARC FURNACE

New improved Model VA-L200H Heraeus 3000-amp furnace, for pilot-plant or small-scale production of pure melts of metals and alloys with high melting temperatures, handles up to 40 lb of titanium or 70 lb of steel; comes with five interchangeable crucibles.—*Rochester Div., Consolidated Electrodynamics Corp., 1775 Mt. Read Blvd., Rochester, N. Y.*

For more information circle **335** on inquiry card.

DRAFTSMAN'S TEMPLATE

New No. 10 Sketch Mate has circles, hexagons, squares and triangles from $\frac{3}{32}$" to $\frac{1}{2}$"; also 5"



scales graduated in 10ths and in 16ths.—*Rapidesign, Inc., P. O. Box 429, Burbank, Calif.*

For more information circle **336** on inquiry card.

CORRECTIONS

Heavy-duty Thermostat: Klixon 20500 Series, Spencer Thermostat Div. (May issue, page 893) is rated **30 amp**—not 3 amp as misprinted.

For more information circle **282** on inquiry card.

Oscillograph: Wrong photo had been attached to M-H Heiland Division's announcement of new Model 906A (May issue, page 882). Illustration below shows which is which:

For more information circle **283** on inquiry card.

1012 906A

1.

The First **COMPUTER HANDBOOK**

Include:
Industrial Uses of Special-Purpose Compute
Industrial Uses of Analog Computers
Industrial Control of Rolling Mill Schedule
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Process Control and the Analog Computer
Digital Computers—General Purpose and DDA

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3.

NUCLEAR REACTORS FOR INDUSTRY AND UNIVERSITIES

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new plants and mergers

MINNEAPOLIS-HONEYWELL has leased a new $350,000 plant from the Greater Fall River Development Corp. of Massachusetts.

FEDERAL ELECTRIC CORP., the service organization of IT&T, is moving its 600 headquarters employees into a new leased office building in Paramus Industrial Park.

CONSOLIDATED ELECTRODYNAMICS has formed a subsidiary in Germany to serve as central sales and service facility for Western Europe and the United Kingdom.

CRUCIBLE STEEL has consolidated all metals research, development and metallurgical activities in a new Technological Department under Dr. M. J. Day, vice-president Technology.

TEXAS INSTRUMENTS has sold its panel instruments manufacturing facilities and product line to Sun Electric Corp.

MEASUREMENTS RESEARCH CO., formerly the Electronics Div of Atlas Precision Products, has become a separate company in the group of the Prudential Industries.

LINDE CO. DIV. of Union Carbide Corp. will build a 300-ton-a-day liquid oxygen-nitrogen plant in California.

AIRBORNE INSTRUMENTS LAB has become the Electronics Division of Cutler-Hammer, Inc., retaining its name, officers, management, personnel, and line of business.

SQUARE D CO. has broken ground for a 10,000-sq-ft regional headquarters building in Pittsburgh, which will also house Electric Controller & Mfg. Co. (acquired two years ago and now operated as a separate division).

people in the news

Frank M. Jenner
Consolidated

K. W. Patrick
Consolidated

CONSOLIDATED ELECTRODYNAMICS, taking final steps of decentralization, has named two new vice-presidents: *Kennett W. Patrick* for the Monrovia Divisions, and *Frank M. Jenner* for the Rochester Division.

INSULATED WIRE
that will withstand
2000°F

- Available in outside diameters of .04 to .32.
- One or more wires insulated with a pure mineral swaged into a metal tube.
- Can be sharply bent.
- Sheath can be welded without loss of insulation.
- Available in a variety of sheath metals with thermocouples and other wire materials.
- Complete thermocouple probes available using this material made to your requirements.

AEROPAK wire will last forever in service—eliminating costly replacement

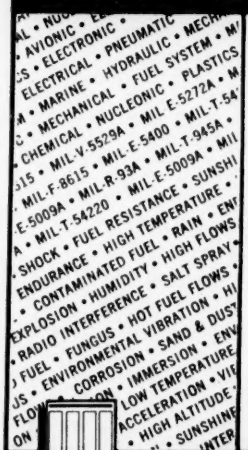
WRITE FOR BULLETIN M-1

Aero Research
INSTRUMENT COMPANY, INC.

315 NO. ABERDEEN STREET, CHICAGO 7, ILLINOIS
Sales Representatives throughout the United States and Canada

For more information circle **101** on inquiry card.

AEROTEST LABS
FOR RELIABLE TESTING OF ALL PRODUCTS TO ALL SPECS



Only at Aerotest will you find a complete single source of diversified testing services—**evaluation** tests to help **design** your product, **sampling** tests to help **build** it, and **qualification** tests to help **sell** it.

Other Aerotest services available to manufacturers include:

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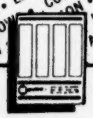

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New revised edition of our designer's wall chart. Useful handbook data—conversion factors, tables, etc. Send for your free copy today.

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For more information circle **102** on inquiry card.

J. L. Saunderson
Baird-Atomic

R. A. Merritt
Cox Instruments

BAIRD-ATOMIC announces that *Dr. Jason L. Saunderson*, vice-president—Chemical Instrument Engineering, will receive an honorary Doctor of Science degree by Morningside College of Sioux City.

GEORGE L. NANKERVIS CO. announced appointment of *Roger A. Merritt* as manager of its **COX INSTRUMENTS DIV.**

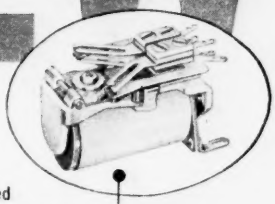
SHEFFIELD CORP's president *Louis F. Polk*, who is also vice president and group executive of the parent organization, **BENDIX AVIATION CORP.**, received an honorary degree of doctor of science from Miami University at Oxford in recognition of his contributions in advancing the art of metrology.

HOFFMAN ELECTRONICS CORP. has appointed *William R. Barnes* director, field service department for the Hoffman Labs Div.

STROMBERG-CARLSON announces appointment of *Clarence F. Van Epps* as director of manufacturing of its Electronics Division.

NEW

COMAR'S TJC RELAY



- Incorporates the best characteristics of the standard telephone type and the small lightweight relay. Features include rugged construction, sensitivity, large contact spring capacity, compact size. Armature is an improved hinge-type, assuring long life and stable adjustment. Independent-action twin contacts insure positive closing. Forms A, B or C available. Rating, 4 amps., 150 watts. Operating voltage, up to 220 V.D.C. Net weight, 2¼ oz.

Offers an **UNUSUAL COMBINATION OF FEATURES** *in a compact relay*

Send for Bulletin TJC

Comar ELECTRIC COMPANY
3349 ADDISON ST.,
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RELAYS
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COILS
SWITCHES
HERMETIC SEALING

For more information circle **104** on inquiry card.

READ any surface temperature with Alnor PYROCON

Equipment...material...metallic or non-metallic...flat, curved... revolving or stationary—you can read every surface temperature accurately in less than 3 seconds!

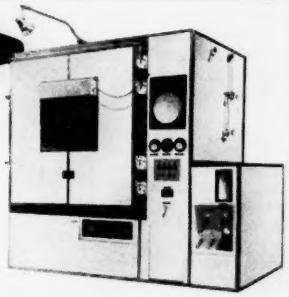
Compact, complete in precision design, this rugged instrument assures highest standards of speed, accuracy and dependability.

Alnor Portable Pyrocons come in scale ranges to 2000° F., with thermocouples for every application. You'll find full details on the Pyrocon exactly suited to your operations in Bulletin 4257. Send for your copy now. Write: Illinois Testing Laboratories, Inc., Room 518, 420 N. LaSalle St., Chicago 10, Ill.

Alnor PRECISION INSTRUMENTS FOR EVERY INDUSTRY

For more information circle **103** on inquiry card.

DEVELCO



SALT SPRAY FOG TEST CHAMBER

To meet MIL-E-5272 and others.

TOP OPENING
FRONT OPENING
WALK-IN

Write for Bulletin SS-55

DEVELCO

DEVELOPMENT ENGINEERING COMPANY

9 Cross Street • Norwalk, Connecticut

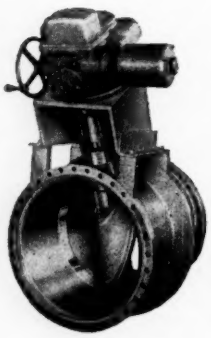
- *Manufacturers of Environmental Test Equipment Fungus Testing - Cold - Heat - Altitude - Humidity*

For more information circle **105** on inquiry card.

Your plant needs

ROCKWELL VALVES *like these*

"Kwikleen" slide valve for powdered coal, granular materials, flue gases with high solids content, etc.; solids accumulations easily cleaned out by removing bottom plate.



"Stress-seal" butterfly valve for tight shut-off of hot, corrosive or dirty gases to 1300° F. and higher, at 200 p.s.i. Alloy stress band in valve body is inflated by external gas pressure to effect tight seal.

Butterfly valve with simplified bracket and linkage to air operator and valve disc positioner; provides maximum adjustment, minimizes friction, eliminates backlash, chatter and hunting, reduces power requirement in close control applications.

"Slim-Jim" wafer type butterfly valve for low pressure air, gas or liquids; low cost, light, simple, space-saving, easy to install.

What's your valve problem?

W. S. ROCKWELL COMPANY
2128 ELIOT STREET
FAIRFIELD, CONN.

For more information circle **106** on inquiry card.

new literature

AUTOMATION

PHOTOELECTRIC CONTROL. 6-page Bulletin 570 covers line of miniature light-sources and pickups, also light-conducting plastic rods, for an extremely wide variety of jobs.—ESS Instrument Co., Bloomfield, N. J.
For more information circle **337** on inquiry card.

CONTROL REACTOR MANUAL. 32-page reference brochure entitled "A Look Inside Tomorrow's Engineering" presents circuit diagrams, fifty characteristic curves, of saturable reactors, etc.—Chicago Magnetic Control, a Div. of Chicago Electronics Engineering Co., Inc., 1616 N. Damen Ave., Chicago 47, Ill.
For more information circle **338** on inquiry card.

MACHINE LOAD CONTROL. 2-page Bulletin AC-6 describes new controller designed to protect machinery and equipment through automatic shut-off, automatic warning and/or continuous on-off operation.—Tipptronic, Inc., Chagrin Falls, Ohio
For more information circle **339** on inquiry card.

MECHANICAL REMOTE CONTROLS. 32-page spiral bound brochure describes an extremely diversified line of cable-type, conduit-type and other controls.—Teleflex Inc., North Wales, Penna.
For more information circle **340** on inquiry card.

VALVES

SAFETY-RELIEF VALVES. 48-page Catalog FE-118 gives detailed information for selection and sizing of nozzle safety-relief valves applicable to process piping; sizing factors and formulae; nozzle capacity charts, and dimension and weight tables.—Farris Engineering Corp., 706 Commercial Ave., Palisades Park, N. J.
For more information circle **341** on inquiry card.

SOLENOID VALVES. 8-page Stock List on valves available for immediate delivery is complete in every respect.—Automatic Switch Co., Hanover Rd., Florham Park, N. J.
For more information circle **342** on inquiry card.

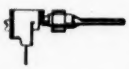
VALVES. 4-page bulletin describes pilot-operated remote-control valves featuring exceptional versatility and exclusive "Space Saver" design.—Febco Inc., 1993 Blake Ave., Los Angeles 39, Calif.
For more information circle **343** on inquiry card.

AIR VALVES. 108-page General Catalog 58 covers: (1) 4-way valves and manifolds; (2) 2-and 3-way line valves; (3) manual valves and manifolds; (4) pilot and special valves; also handy valve selection charts, J.I.C. symbol diagrams, valve feature comparison chart, special circuit applications table and "how-to-do-it" data.—Numatics, Inc., Highland, Mich.
For more information circle **344** on inquiry card.

AIR

COOLING EQUIPMENT. 34-page catalog covers fans and blowers specially designed to fit standard electronic racks, pressurize cabinets with cool filtered air preventing dust from entering through cracks and joints.—McLean Engineering Lab., P. O. B. 228, Princeton, N. J.
For more information circle **345** on inquiry card.

WOVEN WIRE CLOTH. 2-page bulletin covers imported types up to 500 mesh, openings to 2 microns, all metals and alloys, all weaves.—J. R. Mills & Co., 1900 Winnetka Ave., Northfield, Ill.
For more information circle **346** on inquiry card.



TEMPERATURE

MUELLER BRIDGES. 6-page Data Sheet E-33(3) describes Type G-1 and G-2 Mueller Bridges for temperature measurements accurate to 0.01 C°.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.
For more information circle **347** on inquiry card.

HOT BOX DETECTOR. 6-page brochure describes Servosafe Hot Box Detective that measures infrared radiation from freight train journal boxes.—Servo Corp. of America, 2020 Jericho Turnpike, New Hyde Park, N. Y.
For more information circle **348** on inquiry card.

TEMPERATURE CONTROLLERS. 8-page Condensed Catalog 400 covers local and remote-bulb, indicating and non-indicating, single and dual-switch models.—United Electric Controls Co., 85 School St., Watertown 72, Mass.
For more information circle **349** on inquiry card.

HEAT EXCHANGERS, etc., are described in four bulletins: 2-page Bulletin 129 R on Aero vapor condenser, 8-page Bulletin 130 on Aero After Cooler, 4-page Bulletin 132 on Aero Sectional Heat Exchanger, and 1-page Bulletin 136 on Aero Vapor Condenser.—Niagara Blower Co., 405 Lexington Ave., New York 17, N. Y.
For more information circle **350** on inquiry card.

TEMPERATURE CONTROLLERS. Two 2-page bulletins describe (1) Duenna thermocouple-commanded controllers especially suitable for automatizing chemical reactions; (2) Therm-O-Watch Liquid Column Monitor, capacitive type, which attaches directly to a thermometer column and is capable of half-degree sensitivity.—Instruments for Industry Research, 108 Franklin Ave., Cheltenham, Penna.
For more information circle **351** on inquiry card.

PYROMETER SUPPLIES. 16-page catalog describes a complete line of precision-matched pyrometers and thermocouples which can be used interchangeably with any make of py-

rometer or thermocouple thermometer. —Raymond F. McHugh & Son, Box 6025, Phila. 14, Pa.

For more information circle **352** on inquiry card.

LOW TEMPERATURE CONVERSION table, pocket size, is unique in that conversions include degrees Celsius to degrees Fahrenheit and Kelvin from absolute zero to 0°C.—Technical Sales Dept., Trans-Sonics Inc., Burlington, Mass.

For more information circle **353** on inquiry card.

TELEMETERING. 4-page brochure describes BP-20-M System which converts output of resistance-thermometric pickup to signal capable of driving recorder, etc.; provides for twenty B6 type plug-in bridges.—Hesco Engineering, 322 E. Beach Ave., Inglewood, Calif.

For more information circle **354** on inquiry card.

FLOW, LEVEL, PUMPS

FLOW METERING. 16-page pocket-size booklet, "Selecting Primary Flow Elements," assists in selecting the proper differential producer for every flow metering situation. Center-spread table compares devices in terms of accuracy, range, life expectancy, initial and operating cost, recovery differential, weight, laying length, etc.—Builders-Providence, Inc., 345 Harris Ave., Providence 1, R. I.

For more information circle **355** on inquiry card.

FLOW-RATE ELEMENT. 2-page Bulletin 125-P1 describes unique new plastic Venturi nozzle for metering of corrosive fluids.—Builders-Providence, Inc., 345 Harris Ave., Providence 1, R. I.

For more information circle **356** on inquiry card.

LIQUID LEVEL. 2-page Technical Bulletin RF-581 describes Betatrol, a new liquid level sensor which employs a radioactive material in sensing element.—Aeronautical and Instrument Div., Robertshaw-Fulton Controls Co., Anaheim, Calif.

For more information circle **357** on inquiry card.

AUTOMATIC ODORANT METERING. 2-page Application Engineering Data Sheet E-58-2 describes four modern automatic methods to meter and feed a precise ratio of odorant to natural gas lines.—Milton Roy Co., 1300 E. Mermaid Lane, Phila. 18, Pa.

For more information circle **358** on inquiry card.

TREATMENT OF KRAFT MILL WASTES. Data Sheet F-57-1 deals with controlled volume pumps for accurately metering nutrients, to enrich industrial wastes.—Milton Roy Company, 1300 E. Mermaid Lane, Phila. 18, Pa.

For more information circle **359** on inquiry card.

PULSATING FLOW. 12-page Bulletin 91-117, "A Practical Pulsation Threshold for Flowmeters" by V. P. Head, is reprinted from Transaction of the ASME.—Fischer & Porter, 548 Jacksonville Rd., Hatboro, Penna.

For more information circle **360** on inquiry card.

SEWAGE MEASUREMENT. 8-page Bulletin 1200 describes Type "ML" Meter, said to be a "radically new concept in measuring of sewage flow through Parshall Flumes."—Burgess-Manning Co., Penn Instruments Div., 4110 Haverford Ave., Phila. 4, Pa.

For more information circle **361** on inquiry card.

new cox frequency converter

The new Cox Frequency-to-Analog Converter joins the ever growing list of precision instruments designed and built for electronic data handling by the Cox Instruments Division — pioneers in precision flow measuring equipment.

The Type 2 Converter was originally developed for use with the Cox Turbine Flow Measuring System, but is now being widely used in many other applications for extremely linear conversions in telemetering, computers and other transducer-recorder systems. Its high sensitivity, excellent stability and fast transient response combined with low cost, make it an outstanding convertet for all around use.

A new technical bulletin describing the Type 2 Frequency Converter is available upon request. Write to *Cox Instruments Division, George L. Nankervis Company, 15200 Fullerton Avenue, Detroit 27, Michigan.*

SPECIFICATIONS

Range	100 to 5000 cps (other ranges available)
Linearity	.1 per cent over 10:1 range
Stability	.1 per cent
Transient Response	1 millisecond
Price	$300 f.o.b. Detroit

cox instruments

Precision Instruments Since 1912

GLN-258

For more information circle **107** on inquiry card.

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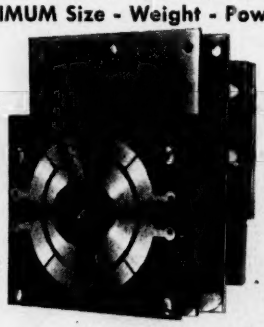
BALLOON

CONTROL INSTRUMENTS

require MAXIMUM Performance

MINIMUM Size - Weight - Power Drain

Brailsford AGC Timers Are Unmatched In These Basic Requirements



Model AGC

If You Have A Timing Problem Where Size, Mass and Power Drain Are Critical Read These

SPECIFICATIONS

Number of decks—1-4 • Speed regulation—±1.0% at 50% voltage shift

Size—1¾" x 2¼"—depth depends on number of decks

Segments per deck—2-8 for stock units.

Special commutators to order for a nominal tool charge.

Shorting or non-shorting contact • Power input—.008 Amp. at 6 VDC

WRITE FOR LITERATURE

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SUB FRACTIONAL WATT D.C. MOTORS SIGNALLING SYSTEM COMPONENT

For more information circle **108** on inquiry card.

Watch your shake tests in slow motion—with the SLIP-SYNC

Provides completely automatic synchronization of stroboscopic lights for watching shake tests in slow motion. Makes the use of strobes practical at high shaker frequencies.

5 CPS to 10 KC

Take slow motion movies with the CAMERA-SYNC

Controlled by the SLIP-SYNC, it operates a pulse type movie camera at slow frame rate, in synchronism with the strobe lights, to yield slow-motion movies of shake tests.

Failures in vibration testing are generally caused by mechanical amplification at resonance. These instruments allow immediate location and analysis of the damaging resonances by observation and/or photography. Literature on request.

CHADWICK—HELMUTH COMPANY

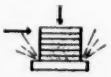
472 East Duarte Road • Monrovia, California

For more information circle **109** on inquiry card.

NEW LITERATURE

FLOW AND VOLUME. 4-page brochure describes Model 257 Flow Measuring System which supplies a d-c signal proportional to flow-rate compensated for temperature, also registers accumulated volume.—Computers Inc., 3407 S. Shepherd Drive., Houston, Tex.

For more information circle **362** on inquiry card.



PRESSURE

PRESSURE CALIBRATORS. 2-page bulletin describes Models D86, D87 and D90 light-weight instruments for field checking of pressure pickups and gages.—Decker Engineering Corp., 7706 Melrose Ave., Los Angeles 46, Calif.

For more information circle **363** on inquiry card.

WAVE ANALYZER SYSTEM. 4-page bulletin describes the TP-625 for analysis of vibration, strain, pressure, etc.—Technical Products Co., Instrument Div., 6670 Lexington Ave., Los Angeles 38, Calif.

For more information circle **364** on inquiry card.

FORCE AND PRESSURE. 8-page brochure describes custom-made measuring and control systems; also components and accessories.—Dynametrics Corp., (Formerly Wind Tunnel Instruments Co., Inc.), Northwest Industrial Park, Burlington, Mass.

For more information circle **365** on inquiry card.

MANOMETERS is title of 12-page booklet giving basic facts and definitions, operating principles, installing, servicing; also tables of equivalents and temperature correction factors.—King Engineering Corp., 400 Detroit St., Ann Arbor, Mich.

For more information circle **366** on inquiry card.

SERVOMANOMETERS. 8-page Bulletin 500 and 4-page Specification Sheet describe manometers using servomechanisms for following top of liquid column. One lab model is "believed to be the most accurate primary standard in existence."—Exactel Instrument Co., 5545 Eva Ave., Los Altos, Calif.

For more information circle **367** on inquiry card.

PRESSURE MEASUREMENT. 4-page Bulletin 5602 and 2-page Price List P-5701 describe Teledyne pressure pickups; 2-page price list P-5700 describes Teledyne Indicator which comes with power supply; 2-page price list P-5704 describes model 194 ac decade amplifier.—Taber Instrument Corp., 111 Goundry St., North Tonawanda, N. Y.

For more information circle **368** on inquiry card.

SPEED, COUNT

SPEED MEASURING SYSTEMS. 8-page Bulletin GED-3259 emphasizes instruments needed for incorporation into process machines.—General Electric Co., Schenectady 5, N. Y.

For more information circle **369** on inquiry card.

IMPULSE COUNTER. 4-page Technical Information E25 describes small impulse counter for preselection Type

TCeF4PE-ro.—Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y.
For more information circle **370** on inquiry card.

ADJUSTABLE-SPEED DRIVE. 8-page Bulletin 34-200 describes new ac Var-EPack System for motors from 1 to 50 hp or higher, choice of several maximum speeds.—The Electric Products Co., 1725 Clarkstone Rd., Cleveland 12, Ohio.
For more information circle **371** on inquiry card.

TACHOMETRY. 12-page Booklet 58 describes benefits of speed indication; includes line drawings with dimensions showing various ways in which tachometers can be installed.—Jones Motrola Corp., P. O. Box 825, Stamford, Conn.
For more information circle **372** on inquiry card.

ANALYTICAL, LABORATORY

TURBIDITY TRANSMITTER. 4-page Product Specification E66-1 describes how turbidity measurements are electrically transmitted to remote indicators and/or recorders by new bolometer transmitter.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.
For more information circle **373** on inquiry card.

GAS ANALYSIS. 4-page Product Specification E65-6 describes gas sampling system which provides a continuous, clean gas sample to gas analyzer.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio
For more information circle **374** on inquiry card.

D-H ANALYZER. 8-page pamphlet lists complete specs. and operating characteristics of improved Model 20609 256-channel Pulse Height Analyzer.—Radiation Counter Labs., Inc., Skokie, Ill.
For more information circle **375** on inquiry card.

PLATINUM PRODUCTS. 24-page catalog covers crucibles, apparatus tubing, precious metals, and chemicals, clad metals, composite metals; also notes on care and use, tables, etc.—J. Bishop & Co. Platinum Works, Malvern, Penna.
For more information circle **376** on inquiry card.

SINGLE SIDEBAND SPECTRA. 8-page Vol. 1 No. 3 of "The Panoramic Analyzer" discusses SSB Transmission uses, comparison with other modulating systems, methods of testing linearity, etc.—Panoramic Radio Products, Inc., 514 S. Fulton Ave., Mt. Vernon, N. Y.
For more information circle **377** on inquiry

FLAME ANALYSIS FOR MAGNESIUM. 4-page Application Data Sheet DU-84-B describes a simple flame photometric technique for determining minute quantities of magnesium in body fluids.—Beckman/Scientific Instruments Div., Fullerton, Calif.
For more information circle **378** on inquiry card.

CHROMATOGRAPHY. 4-page Data Sheet GC-82-MI describes time-saving benefits of two column gas chromatography, using the maker's Dual Column Valve.—Beckman/Scientific Instruments Div., Fullerton, Calif.
For more information circle **379** on inquiry card.

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For more information circle **115** on inquiry card.

NEW LITERATURE

SPECTROPHOTOMETER. 8-page Bulletin B-241 describes Universal Spectrophotometer now offered with a choice of four power supplies and with accessories for nephelometry and fluorimetry.—Coleman Instruments, Inc., 318 W. Madison St., Maywood, Ill.

For more information circle **380** on inquiry card.

LAB INSTRUMENTS. Four announcements describe Model HD 1 Stoll-Hardy Radiometer, Model ER2-ES2 Hardy-Wolf-Goodell Dolorimeter, Model HF2 Portable Potentiometer, Model HG3 Activity Cage.—Williamson Development Co., Inc., 317 Main St., Concord, Mass.

For more information circle **381** on inquiry card.

CHROMATOGRAPHY. 12-page Bulletin No. 837 describes Model K-5 Kromo-Tog, an advanced new research instrument for analysis by gas and vapor chromatography.—Burrell Corp., 2223 Fifth Ave., Pittsburgh 19, Pa.

For more information circle **382** on inquiry card.

LAB BALANCES. 4-page form 3270 describes three new Shadograph balances, also a balance for centrifuge cups and general lab weighing, and a Precision Automatic Net Weighing Machine.—The Exact Weight Scale Co., 538 East Town St., Columbus 15, Ohio.

For more information circle **383** on inquiry card.

NUCLEONICS

NUCLEONICS. 40-page catalog A-2 describes a complete new line of atomic instrument systems to measure and analyze radioisotopes in industrial, medical and biological applications.—Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass.

For more information circle **384** on inquiry card.

GAS-COOLED REACTOR. 16-page reprint of a report presented at the Symposium on Nuclear-powered Merchant Ships.—Ford Instrument Co., Div. of Sperry Rand Corp., 31-10 Thomson Ave., Long Island City 1, N. Y.

For more information circle **385** on inquiry card.

RADIATION DETECTION. Latest issue of "The NMC Fallout" describes AM-33 air monitor, PCS-1 paper chromatograph scanner, and PC-3A proportional counting system.—Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

For more information circle **386** on inquiry card.

OPTICAL

ALIDADES. 36-page pocket-size Service Booklet C on use and adjustment of alidades includes tables by which the field man can obtain horizontal distances and elevations from stadia readings, also helpful information on exploration and map-making, detailed instruction on stadia surveying and use of the Beaman Stadia Arc, etc.—Alidade Department, W. & L. E. Gurley, 514 Fulton St., Troy, N. Y.

For more information circle **387** on inquiry card.

PHOTOGRAPHIC INSTRUMENTATION. 6-page folder describes a wide selection of high-performance photographic instrumentation cameras and accessories.—Traid Corp., 17136 Ventura Blvd., Encino, Calif.

For more information circle **388** on inquiry card.

FUSED QUARTZ AND GLASS parts are covered in 4-page bulletin—Dell Optics Co., Limited, 327-55th St., West New York, N. J.

For more information circle **389** on inquiry card.

ELECTRON MICROSCOPE. 6-page folder gives engineering data on Norelco EM-75B Electron Microscope.—Instruments Div., Philips Electronics, Inc., 750 South Fulton Ave., Mount Vernon, N. Y.

For more information circle **390** on inquiry card.

DATA HANDLING

ANALOG COMPUTER COMPONENT. 4-page technical bulletin and 2-page Application Note cover new K 5-U Universal Linear Operator.—George A. Philbrick Researches, Inc., 230 Congress St., Boston 10, Mass.

For more information circle **391** on inquiry card.

DATA PROCESSING. 4-page Vol. 1 No. 5 issue of "Filmsort Facts" features article "Better Equipment Needs Better Film" by D. W. McArthur.—The Filmsort Co., Pearl River, N. Y.

For more information circle **392** on inquiry card.

TAPE REELS. 2-page bulletin gives design and construction details of Precision Tape Reels.—Ampex Corp., 934 Charter St., Redwood City, Calif.

For more information circle **393** on inquiry card.

ELECTRONIC SWITCHING. 4-page Application Notes, Vol. 1, No. 4, "High Speed Zener Switching Circuits," gives detailed information on high-speed electronic switching necessary for computers.—Hoffman Electronics Corp., Semiconductor Div., 930 Pitner Ave., Evanston, Ill.

For more information circle **394** on inquiry card.

TESTING, GAGING

CONCRETE TESTING. 6-page Bulletin CT-711 describes concrete testing machines and accessory equipment.—Soiltest, Inc., 4711 W. North Ave., Chicago 39, Ill.

For more information circle **395** on inquiry card.

GAGE BLOCKS. 2-page catalog sheet covers "Shop-Blocks", low-priced Grade A gage blocks.—The DoAll Company, Des Plaines, Ill.

For more information circle **396** on inquiry card.

HARDNESS TESTER. 8-page Bulletin R-12 describes Shore Durometer, international standard for indentation hardness of elastomers.—The Shore Instrument & Mfg. Co., Inc., 90-35 Van Wyck Expressway, Jamaica 35, N. Y.

For more information circle **397** on inquiry card.

CONCRETE TESTER. 2-page bulletin describes 125-ton capacity Model QC-100-SLD Compression and Flexure Tester. Also a tons-to-psi conversion chart mounted on cardboard.—Forney's Inc., Tester Div., P. O. B. 310, New Castle, Penna.

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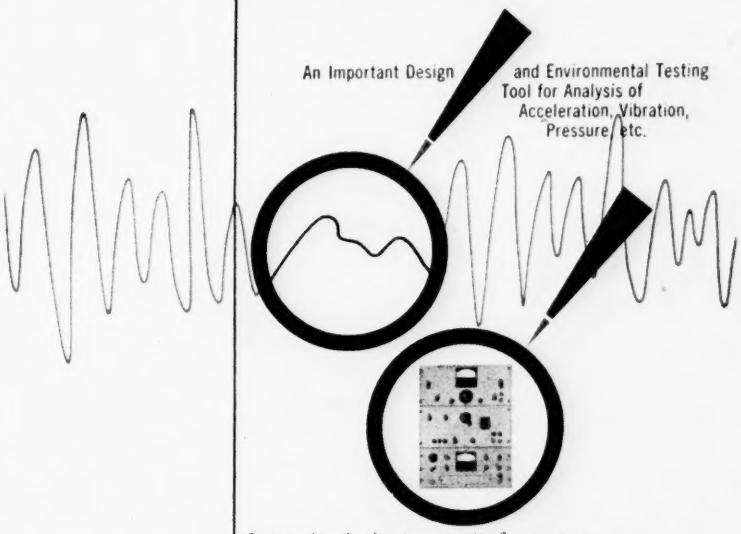

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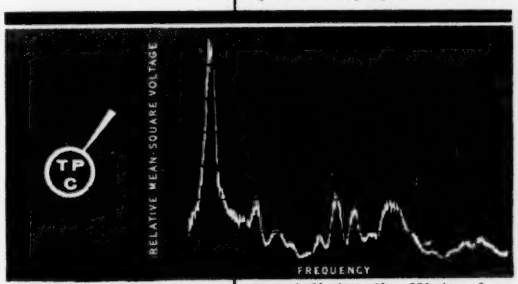

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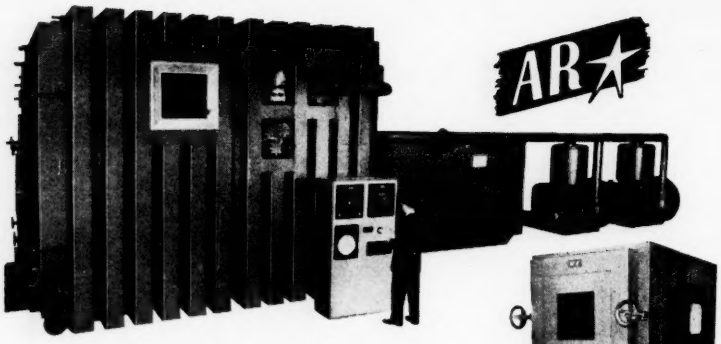

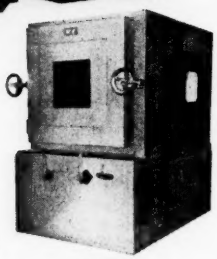

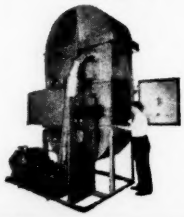

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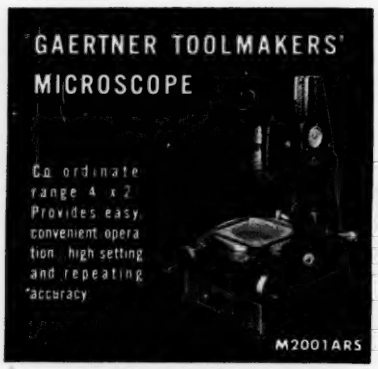

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NEW LITERATURE

CREEP RUPTURE TESTER is described in 4-page brochure.—Arcweld Mfg. Co., P. O. B. 311, Grove City, Penna.

For more information circle **399** on inquiry card.

TUBING, FITTINGS

PNEUMATIC LINES. 4-page Product Specification G91-9 describes Armortube Cable, a flexible, armored, multiple-tube transmission line for pneumatic and hydraulic metering and control systems.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

For more information circle **400** on inquiry card.

HOSE ASSEMBLIES. 4-page Form 101 describes Teflon Lined Flexible Hose Assemblies.—The Mic-Lin Co., Rt. 38 at Rudderow Ave., Maple Shade, N. J.

For more information circle **401** on inquiry card.

LINED PIPE. 4-page Bulletin TS-1 describes Teflon-lined Fluoroflex-T Type S corrosion-proof and fittings. —Resistoflex Corp., Roseland, N. J.

For more information circle **402** on inquiry card.

ITV

ITV. 8-page booklet titled "How Many Jobs" pictures and briefly describes 19 applications of closed-circuit TV, also covers basic and special-purpose cameras, monitors and accessories.—General Precision Lab. Inc., 63 Bedford Rd., Pleasantville, N. Y.

For more information circle **403** on inquiry card.

CC TV. 4-page Bulletin ECL-65 describes new Type TE-6-A single-unit low-cost closed-circuit television camera.—General Electric Co., Industrial Electronics Div., Electronics Park, Syracuse, N. Y.

For more information circle **404** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

GALVANOMETERS. 12-page Bulletin 301 covers Series M Sub-Miniature Galvanometers.—Heiland Div., Minneapolis-Honeywell, 5200 E. Evans Ave., Denver 22, Colo.

For more information circle **405** on inquiry card.

VARIABLE TRANSFORMERS. 4-page Bulletin SE-I. 2583 describes new Series 117 and 217 units and ganged assemblies featuring higher current ratings and increased ratings on constant-impedance loads.—The Superior Electric Co., 83 Laurel St., Bristol, Conn.

For more information circle **406** on inquiry card.

RMS VOLTMETER. 4-page Bulletin B-603 describes a true high-precision rms instrument not to be confused with those using biased diodes or other synthetic rms-sensitive circuitry.—Millivac Instruments, P. O. B. 997, Schenectady, N. Y.

For more information circle **407** on inquiry card.

TRANSISTOR INVERTER. Binder contains sheets describing a 60-va 115-vac transistor inverter for airborne

applications requiring precision 400-cps frequency.—Varo Mfg. Co., Inc., 2201 Walnut St., Garland, Tex.
For more information circle **408** on inquiry card.

ELECTRONIC INSTRUMENTS. 12-page Vol. 32 No. 11 of General Radio Experimenter contains articles on new broadcast monitors, R-C oscillator, FCC-approved TV monitor, etc.—General Radio Co., Cambridge, Mass.
For more information circle **409** on inquiry card.

ELECTRICAL TESTERS. 24-page pocket folder describes comparison bridges, megohmmeters, VTVM's, etc.—Freed Transformer Co., Inc., 1738 Weirfield St., Brooklyn (Ridgewood) 27, N. Y.
For more information circle **410** on inquiry card.

VOLT-AMMETER. 4-page Vol. 9 No. 7 of "hp Journal" is a full description of "An Increased Sensitivity Micro Volt-Ammeter Using a Photoconductive Chopper."—Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.
For more information circle **411** on inquiry card.

LABORATORY STANDARDS. 8-page Short Form Catalog DD describes signal generators, test sets, crystal calibrators, etc.—Measurements Corp., Boonton, N. J.
For more information circle **412** on inquiry card.

TURRET ATTENUATOR. 2-page bulletin describes new 10-position turret precision attenuator which features "Pull-Turn-Push" detent action, and frequency range of dc to 3000 Mc.—Stoddart Aircraft Radio Co., Inc., 6644 Santa Monica Blvd., Hollywood 38, Calif.
For more information circle **413** on inquiry card.

CONSTANT VOLTAGE TRANSFORMERS. 4-page Bulletin CV 308 points out significant reductions in size and weight of new 2-kva 3-kva units and gives technical data.—Sola Electric Co., 4633 West 16th St., Chicago 50, Ill.
For more information circle **414** on inquiry card.

PHASE SEQUENCE INDICATOR, pocket size, is described in 2-page bulletin.—Master Specialties Co., 956 E. 108th St., Los Angeles 59, Calif.
For more information circle **415** on inquiry card.

VOLTAGE SOURCES. 6-page brochure describes line of Precision Power Oscillators for use in electronic systems.—Electronics International Co., 145 W. Magnolia Blvd., Burbank, Calif.
For more information circle **416** on inquiry card.

ELECTRONIC VOLTMETER. 4-page bulletin describes new Model 300D for measuring 0.001 to 1000 volts from 10 to 250,000 cps; gives six frequency-response curves and four stability curves.—Ballantine Labs., Boonton, N. J.
For more information circle **417** on inquiry card.

ELECTRICAL INSTRUMENTS. 16-page Spring 1958 issue of "This Month" catalogs hundreds of new and surplus pieces of equipment including electrical instruments, small motors, components.—Herbach & Rademan Inc., 1204 Arch St., Phila. 7, Pa.
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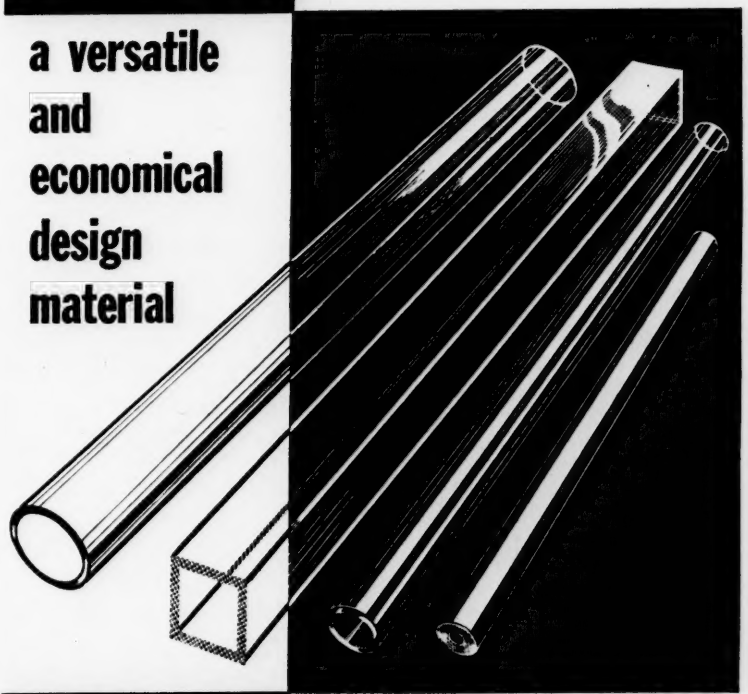

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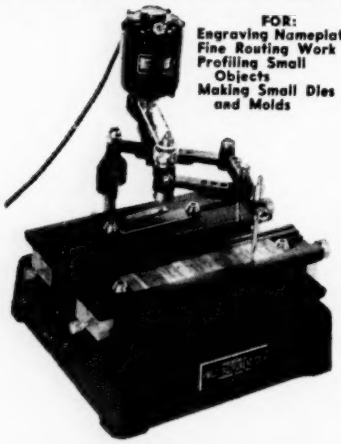

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OSCILLOSCOPE. 2-page bulletin describes portable "Serviscope" said to be equalled in performance only by instruments costing and weighing four times as much.—The Scopes Co., Inc., 22-02 Raphael St., Fairlawn, N. J.

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DECADE SCALER. 2-page Bulletin DS-1A describes an improved decade scaler for precision counting and registering of electrical impulses.—Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

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VOLTAGE-to-DIGITAL CONVERTER. 4-page brochure describes new transistorized Voldicon capable of 2000 separate conversions per second.—Adage, 292 Main St., Cambridge 42, Mass.

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COAXIAL TUNERS. 4-page Catalog No. 7B (Supplement to Catalog 7) announces a new line of line stretchers, double-slug tuners and double-stub tuners.—Microlab, Livingston, N. J.

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PULSE GENERATORS. Two specification sheets cover Model 3450B 2-Mc Pulse Generator and Model 3460A Megacycle Double Pulse Generator.—Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

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TUBES, TRANSISTORS

MICROWAVE TUBES. 36-page catalog covers Klystrons, BWO's TWT's, and related components.—Varian Associates, 611 Hansen Way, Palo Alto, Calif.

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ELECTRON TUBES. 20-page third edition of "Easy-Guide for Reliatron Tubes Industrial and Special Purpose Types" includes new sections on camera and radiation-detection tubes; microwave devices now cover magnetrons. Data are provided in convenient form for maintenance men in industrial plants.—Westinghouse Electronic Tube Div., P. O. Box 284, Elmira, N. Y.

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TRANSISTORS. 4-page folder PA-176 describes the CBS-Hytron Transistor Home-Study Course, includes a complete table of contents for each lesson.—CBS-Hytron Advertising Service, Parker St., Newburyport, Mass.

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STATIC CONTROL, MAGNETS

SWITCHING REACTORS. 16-page catalog on company's complete line of standard switching reactors for one-step low-cost static control.—Control, Div. of Magnetics, Inc., Butler, Penna.

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MAGNETS, etc. 2-page bulletin and 4-page pocket folder cover scribers, magnets, etc.—Spring Specialty Co., 23 N. 5th Ave., Maywood, Ill.

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MAGNETS, etc. 12-page Catalog No. PR-19 lists over 70 Cast Alnico V magnets and over 30 Sintered Alnico II magnets; also demagnetizers and a complete line of electro and permanent magnetizers.—The Indiana Steel Products Co., Valparaiso, Ind.

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SWITCHES, RELAYS

MINIATURE CHOPPERS. Syncroverter Data File contains a number of individual spec sheets on various models of Syncroverters and a 4-page descriptive bulletin.—The Bristol Co., Aircraft Components Div., Waterbury 20, Conn.

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PUSHBUTTON SWITCHES. 8-page Data Sheet 133 covers maker's "50PB" line of precision lighted pushbutton switches.—Micro Switch, a Div. of Minneapolis-Honeywell Reg. Co., Freeport, Ill.

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MULTI-CONTACT RELAY. 4-page engineering bulletin covers new Type 2, used in switching circuits and industrial controls.—Phillips Control Corp., 59 W. Washington St., Joliet, Ill.

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DC-AC CHOPPERS. 4-page Catalog 515 covers miniature low-noise types for 50, 60, 94 and 120 cps.—Stevens-Arnold Inc., 7 Elkins St., South Boston 27, Mass.

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RESISTORS

50-KW RF LOAD RESISTOR. 2-page engineering Bulletin No. 54 describes new unit for use as dummy load, power measurement, high-power line termination or adjustable RF impedance.—Rixon Electronics Inc., 2414 Reedie Dr., Silver Spring, Md.

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TRIMMING RESISTORS. 6-page catalog and several 2-page bulletins cover a wide variety of "Trimpots," and "Trimits."—Bourns Labs., Inc., P. O. Box 2112, Riverside, Calif.

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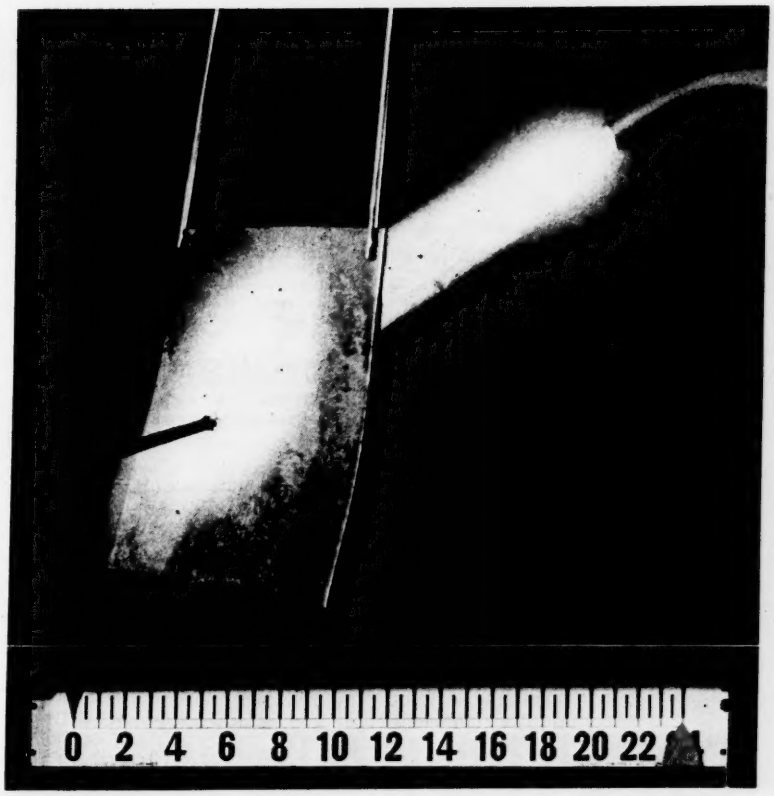

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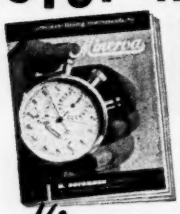

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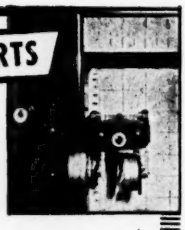

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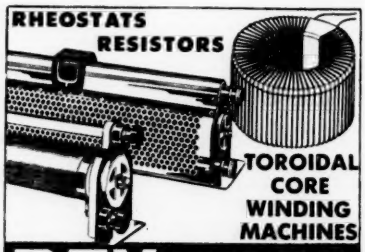

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POWER SUPPLIES. 10-page catalog describes Selenium Rectifier ac to dc standard and special underground service Power Units, also standard and station-type Battery Chargers. —Syntron Co., 702 Lexington Ave., Homer City, Penna.
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AC POWER SOURCE. 2-page bulletin describes Invertron, a completely electronic a-c power source available in many models, with fixed or variable frequencies.—Behlman Engineering Co., 2911 Winona Ave., Burbank, Calif.
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SEMI-CONDUCTOR POWER SUPPLY. 2-page Brochure ES-4000 describes new PS-4000A transistorized power supply providing 260-300 vdc, 0-1.5 amp.—Power Sources, Inc., Burlington, Mass.
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ELECTRICAL COMPONENTS. 24-page Catalog BED-A56 covers eight series of "Micropots" including their rating curves; concentric-scale and digital-reading "Microdials," also instrument motors, etc.—Borg Equipment Div., The George W. Borg Corp., 120 S. Main St., Janesville, Wisc.
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PHOTOCELLS. 12-page Bulletin 3218-1 describes complete line of self-generating photoelectric cells; gives construction details, performance characteristics, power output charts, electrical circuit diagrams for typical applications, and suggested uses.—Vickers, Inc., Electric Products Div., 1815 Locust St., St. Louis 3, Mo.
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tors, and 5 models of circulators and circulator switches.—Cascade Research Div. of Monogram Precision Industries, Inc., Los Gatos, Calif.
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VT HEATERS. 4-page issue of Application Notes on use of semi-conductors is "Improved Regulation of Vacuum Tube Heaters Through Bridge Nulling of Zener Impedance."—Hoffman Electronics Corp., Semiconductor Div., 930 Pitner Ave., Evanston, Ill.
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TERMINALS. "Press-Fit Terminalogy" is title of a new bi-monthly 4-page magazine for terminal users.—Sealectro Corp., 610 Fayette Ave., Mamaroneck, N. Y.
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CIRCUIT MODULES. 2-page Engineering Bulletin No. 55 describes transistorized plug-in modular units.—Rixon Electronics Inc., 2414 Reedie Dr., Silver Spring, Md.
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ELECTRICAL COMPONENTS. 28-page Catalog S-58 gives prices, schematics, dimensional drawings on hundreds of jacks, plugs, switches, etc.—Switchcraft, Inc., 5555 N. Elston Ave., Chicago 30, Ill.
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DELAY LINES. 4-page Data Sheet 107 covers wide selection of lumped-constant delay lines.—Control Electronics, Huntington Station, L. I., N. Y.
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CAPACITORS. 6-page Bulletin C-81 describes Dilectron Ceramic Disc Capacitors, details of various wide variety of capacitance and voltage ratings, temperature-compensating, general-application, special high-voltage, and printed-circuit styles.—Dilectron Div., The Gudeman Co. of Calif., Inc., 2669 South Myrtle Ave., Monrovia, Calif.
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DELAY LINES. 2-page bulletin describes a new series of round-cased continuously-variable distributed delay lines.—PCA Electronics, Inc., 16799 Schoenborn St., Sepulveda, Calif.
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WIRE, CONNECTORS

THERMO ELEMENT WIRE. 4-page reprint of articles by George M. Hickey and J. C. Chaston, includes a calibration table.—J. Bishop & Co. Platinum Works, Malvern, Penna.
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CONNECTOR. 2-page technical bulletin describes hermetic seal series 1400 connector available in 51 and 55 contacts.—Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, New York.
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ELECTRICAL CONNECTIONS. 4-page Bulletin No. 14 is an article "Would You Recognize A Reliable Electrical Connection If You Saw It?" by R. George Roesch.—The Eraser Co., Inc., Syracuse 4, N. Y.
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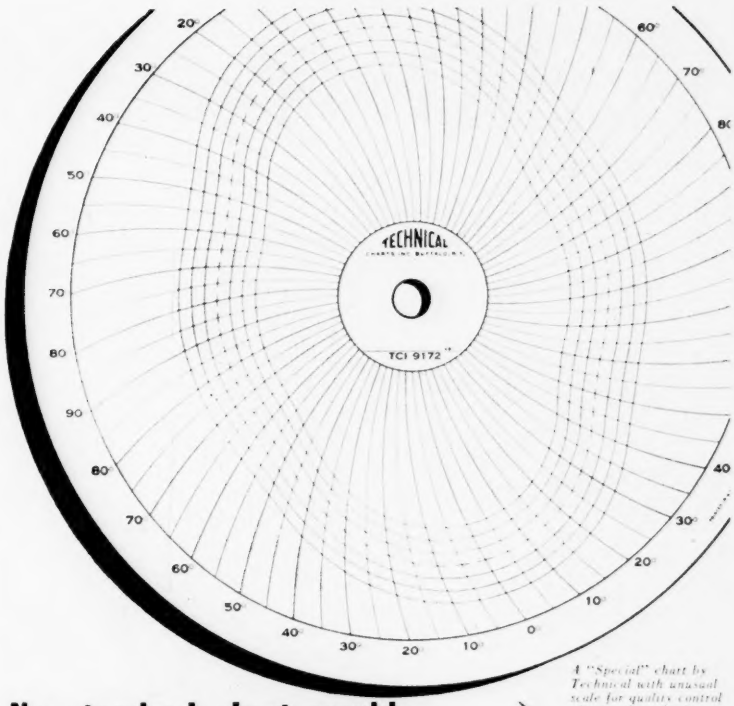

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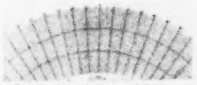

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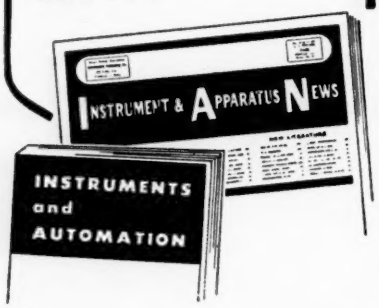

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INSULATED WIRES AND CABLES. 24-page brochure, titled "An Introduction to BIW," describes facilities as well as products, includes a full-page table on comparative characteristics of cable insulations, said to be "probably the most complete and concise presentation of insulation properties available." Boston Insulated Wire & Cable Co., 65 Bay St., Boston 25, Mass.
For more information circle 457 on inquiry card.

MECHANICAL, ELECTROMECHANICAL COMPONENTS

BREADBOARD PARTS. 24-page Catalog 575 lists 117 standard electromechanical breadboard parts, cross-indexed for easy reference.—Beckman/Helipot Corp., Newport Beach, Calif.
For more information circle 458 on inquiry card.

RUPTURE DISCS. 2-page bulletin describes new units made of graphiton fine-grained homogeneous graphite.—The Carbone Corp., Boonton, N. J.
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SLIP RINGS. 6-page pocket folder and 2-page bulletin describe and give specs of custom-built subminiature slip-rings.—Electro Development Co., 14701 Keswick St., Van Nuys, Calif.
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STEEL BALLS. 4-page Bulletin 102 covers low-cost commercial-type carbon steel balls; includes data for designers, also maintenance and repair men.—Hoover Ball and Bearing Co., Ann Arbor, Mich.
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SPECIAL BEARINGS. 24-page Bulletin AFB-2 describes requirements for anti-friction bearings of unusual shapes and sizes, gives data on suitable bearing component materials for high-temperatures, corrosion resistance, non-magnetic properties, etc. —Industrial Tectonics, Inc., 3686 Jackson Rd., Ann Arbor, Mich.
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PRECISION BALLS. Single-page chart shows relative electric and magnetic properties of the most widely used precision ball materials.—Hartford Steel Ball Co., West Hartford, Conn.
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JEWEL BEARINGS. 2-page list of jewel bearings, available from stock, covers more than 30 sizes and types. —Swiss American Jewel Bearings Co., 32-30 58th St., Woodside 77, N. Y.
For more information circle 464 on inquiry card.

COUPLINGS. 4-page Bulletin 56 covers standard gear coupling, Francke flexible, 162 "M" nylon, Junior, Anchor Cut-Out, etc.—John Waldron Corp., New Brunswick, N. J.
For more information circle 465 on inquiry card.

DIALS, SCALES, ETC. 4-page brochure titled "Precision Marking and Fabrication In all Metals, Plastics, and Phenolics" describes manufacture of precision engraved parts.—Gray Pantograph Engraving Co., 200 Washington St., Hoboken, N. J.
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MATERIALS

PLASTICS. 28-page Technical Plastics Form S-358-75 describes company's full line in detail, including properties and characteristics and Government specs.—Synthane Corp., Oaks, Penna.
For more information circle 467 on inquiry card.

METAL STRIP. 6-page pocket folder is designed to help the electronics engineer select the right precision-rolled metal strip for his specific application.—American Silver Co., 36-07 Prince St., Flushing 54, N. Y.
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ADHESIVE FELT. 2-page Product Data Sheet No. 187 describes Self-Sticking Quik-Felt, protects materials during handling, shipping and storage, isolates motor hum, etc.—W. H. Brady Co. 727 W. Glendale Ave., Milwaukee 9, Wisc.
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PLASTIC MATERIALS. 144-page catalog covers most plastics in production today: sheets, rods, film, tubing and specialized plastics; gives technical information, properties and descriptions.—Delta Products, 1400 Henderson, P. O. B. 1440, Forth Worth 1, Texas.
For more information circle 470 on inquiry card.

HIGH TEMPERATURE INSULATION. 8-page technical bulletin A-58 describes Isomica-epoxy micaceous insulation for Class B electrical equipment.—Mica Insulator Div., Minnesota Mining & Manufacturing Co., Schenectady, N. Y.
For more information circle 471 on inquiry card.

PRESSURE-SENSITIVE PAINTS. Circular describes paints whose resistance changes with force, pressure or strain.—Clark Electron Laboratories, Research Products Div., Box 2508, Palm Springs, Calif.
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MISCELLANEOUS

MISSILE RELIABILITY. March-April 1958 issue of "Cannonade" features an article on this subject by Don Drake.—Cannon Electric Co., P. O. Box 3765, Terminal Annex, Los Angeles 54, Calif.
For more information circle 473 on inquiry card.

SINGLE SIDEBAND SPECTRA are the topic of discussion in Vol. 1 No. 3 issue of "The Panoramic Analyzer." Uses, methods of testing linearity, etc., are covered.—Panoramic Radio Products, Inc., 514 S. Fulton Ave., Mt. Vernon, N. Y.
For more information circle 474 on inquiry card.

FREQUENCY GENERATION PROBLEM. 4-page reprint of Nonlinear Circuit Analysis Conference paper by M. J. DiToro treats mathematically the problem posed by pressure of additive noise in a nonlinear standard FG system.—Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.
For more information circle 475 on inquiry card.

SHOP EQUIPMENT

PORTABLE LATHES. Two 4-page leaflets describe improved 12-lb motor-driven lathes with 3" swing, 300 to 3000 rpm speed range, many attachments and accessories.—MasterSon Engineering Co., P. O. B. 24016, Los Angeles 24, Calif.
For more information circle 476 on inquiry card.

PRESSES, etc. Two 4-page and two 2-page bulletins describe (1) air-hydraulic die trim press, (2) fast-production gap type hydraulic press, (3) air-hydraulic speed press, (4) miscellaneous hydraulic and air-hydraulic production equipment.—Studebaker Hydraulic Products Co., 1733 N. 33rd Ave., Melrose Park, Ill.
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SERVICES, FACILITIES

INSTRUMENT REPAIR SERVICE. Folder EN (6) describes a new 4-echelon factory instrument repair service, available through field offices, whereby user may specify type of repair to be made on his equipment.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.
For more information circle 478 on inquiry card.

FACILITIES. 12-page brochure describes company's engineering, manufacturing and testing facilities, together with brief biographical sketches of its key personnel.—Waugh Engineering Co., 7842 Burnet Ave., Van Nuys, Calif.
For more information circle 479 on inquiry card.

FACILITIES, etc. 16-page spiral-bound brochure, titled "Polytechnic Research," describes facilities of firm best known for having invented, developed and named the original "Technicolor" process.—Comstock & Wescott, Cambridge, Mass.
For more information circle 480 on inquiry card.

DATA CONTROL FACILITIES. 20-page brochure, "First in Data Control," covers personnel, engineering, production, etc.—Epsco, Inc., 588 Commonwealth Ave., Boston 15, Mass.
For more information circle 481 on inquiry card.

RUBBER & SYNTHETICS. 6-page brochure describes in detail various types of products and maker's facilities such as individually controlled hydraulic presses, area for manufacture of rubber-to-metal bonded parts.—Mechanical Rubber Products Co., 35 Vail Rd., Warwick, N. Y.
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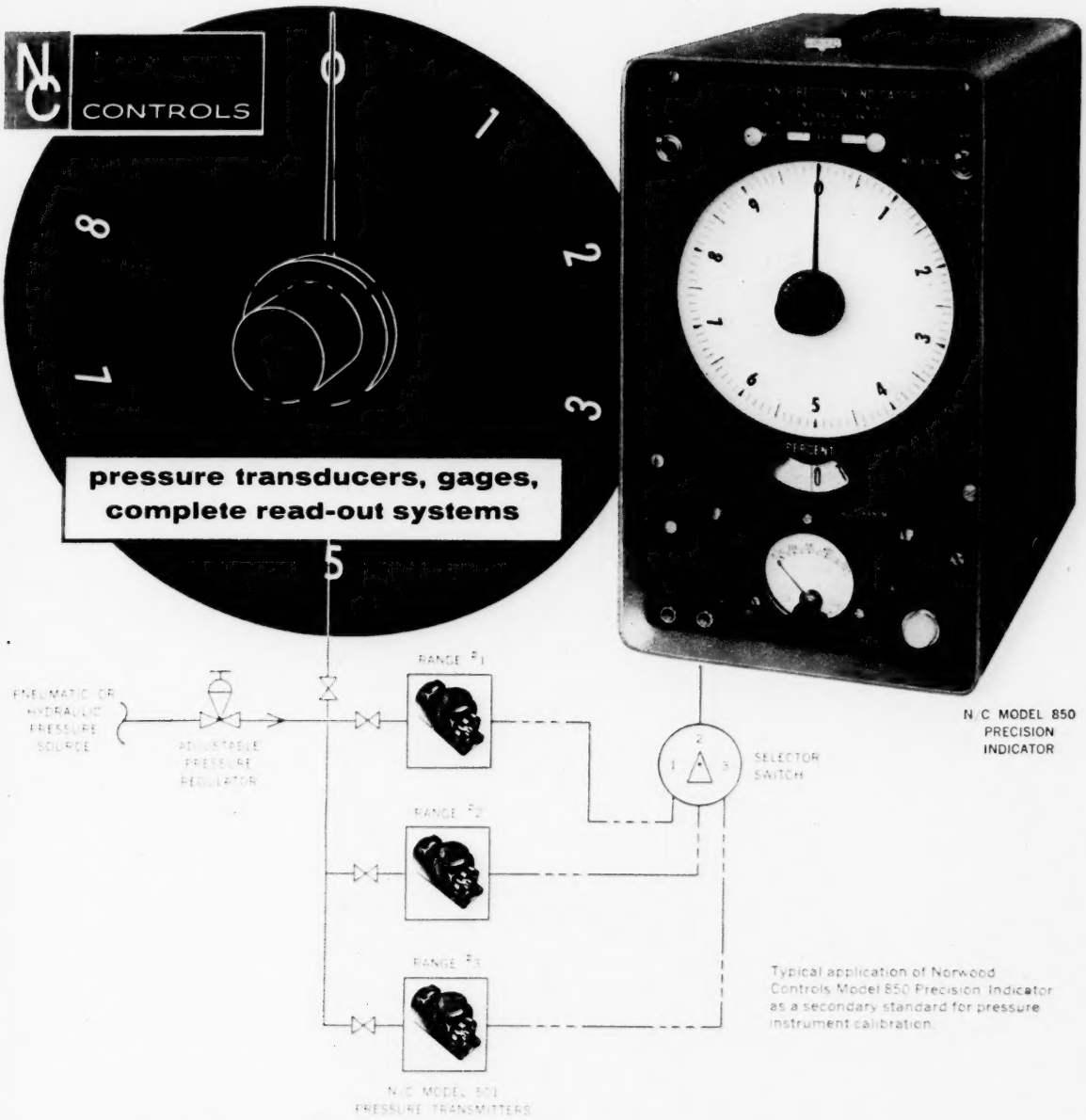
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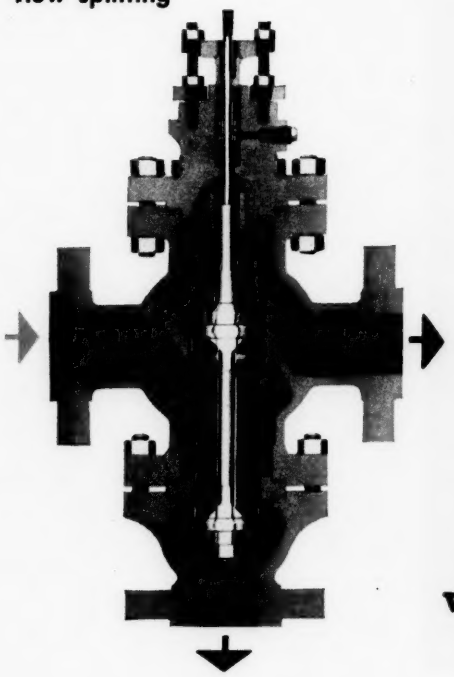

1
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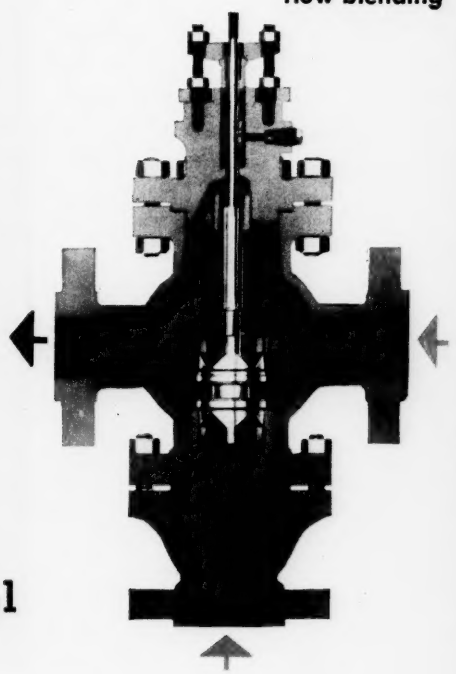

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